MODELING THE COMMON GROUND FOR DISCOURSE PARTICLES

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Abstract

German modal or discourse particles make a contribution to the illocutionary force of an utterance. In this paper we integrate a model of belief sets held as part of the Common Ground into the Abstract Knowledge Representation (AKR) component of the German ParGram grammar. We follow recent accounts that divide the Common Ground into individual belief state sets for each of the discourse participants. We extend the existing German ParGram grammar to be able to parse (short) dialogs and to provide "pragmatic parsing" that integrates information about the belief state of discourse participants. Within this architecture, we provide an analysis of discourse particles that is theoretically well-motivated and can simultaneously be employed in an applied computational context.

1 Introduction

This paper presents an augmentation of the existing Abstract Knowledge Representation (AKR) integrated into the ParGram architecture (Bobrow et al. 2007). The augmentation provides a modeling of the Common Ground (CG) (Gunlogson 2002, Stalnaker 2002). Through this augmentation, we are able to model belief states and allow for the computational drawing of inferences based on belief states.

We illustrate our computational modeling of the CG via an analysis of German discourse particles, which are known to contribute to the illocutionary force of an utterance. A subset of the about 20 discourse particles used in German has been analyzed as signaling information that is pertinent to the CG. Consider (1), for example, where the discourse particle *ja* serves to establish or reconfirm the proposition p as being part of the CG (Lindner, 1991, Kratzer, 1999, Zimmermann, 2011). In (1) the speaker wants to establish that the dog in question is a watch dog (rather than, for example, a hunting dog).

(1) Das ist **ja** ein Wachhund.
That is **yes** a watch dog
'This is a watch dog (as I want to establish).'

Within LFG, the only existing treatment of German discourse particles that we are aware of is their implementation as part of the German ParGram grammar (Dipper, 2003), where they are analyzed syntactically as adverbs and functionally as adjuncts. Our interest is concentrated on the interface between syntax and semantics/pragmatics and we thus extend the existing ParGram implementation. This extension essentially provides a parser capturing formal pragmatic intuitions about discourse analysis: a pragmatic parser.

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The pragmatic parser uses syntactic and semantic information to produce a discourse model. The first step in devising this model is to organize the beliefs of the discourse participants (who believes what). We adopt the set-theoretic assumptions of Gunlogson's (2002) work. Throughout the discourse parsing, these beliefs are manipulated and changed with each new contribution to the discourse. Thus, a crucial task is to determine the intention of a certain contribution or utterance. Our current approach to this is to assume that utterances represent a small set of discourse moves such as rejection or acceptance. Our model allows for a check for logical consistency among discourse moves, an essential component for the analysis of discourse moves (Walker, 1996).

The German ParGram grammar already contains a basic semantic component (Zarrieß 2009a,b) that is realized within the AKR system. AKR has been used primarily for computational purposes such as Question-Answering (Q&A) systems (Condoravdi et al. 2003, Bobrow et al. 2007) and is thus in principle already set up for discourse processing. We integrate a pragmatic analysis of discourse particles via the XFR rewriting system (Crouch and King 2006, Crouch et al. 2008) and extend the AKR component to model CG based on Gunlogson.

2 Discourse Particles

German has a rich inventory of *discourse* or *modal* particles (von der Gabelentz 1891, Jacobs 1983, 1991, Abraham 1991, König 1997, Coniglio 2011). These particles have very subtle pragmatic content and contribute to the illocutionary force of an utterance (e.g., Karagjosova 2003, 2004, Bayer and Obenauer 2011). A subset of the German discourse particles establishes/invokes information with respect to a common ground (Zimmermann 2011), including *ja* 'yes', *doch* 'indeed' and *wohl* 'presumably'. We focus on these three, (2)–(4).[1]

(2) a. Das weißt du **ja**.
that know you **yes**
'You know that (already).'

b. Der Zug hat **ja** dann hinterher eine umso höhere Lageenergie.
the train has **yes** then afterwards an even higher potential energy
'The train will (of course) then afterwards have a higher potential energy.'
(from S21)

(3) a. Das ist **doch** klar.
that is **indeed** clear
'That is clear (as you ought to know).'

[1] A number of our examples are taken from the Stuttgart 21 mediation (S21) process, a public political discussion investigated as part of the *VisArgue* project on understanding political argumentation. Discourse particles were found to play a role in the framing of argumenation.

b. Es fährt **doch** ein TGV von Straßburg nach Stuttgart?
it drives **indeed** a TGV from Strasbourg to Stuttgart?
'There is a TGV from Strasbourg to Stuttgart, right?' (from S21)

(4) a. Er ist **wohl** nicht zu Hause.
he is **presumably** not at home
'Presumably he is not at home.'

b. Vielmehr ist es **wohl** genau so diskutiert worden.
rather is it **presumably** exactly so discussed become
'Rather, it has presumably been discussed exactly like that.' (from S21)

All three are very common German discourse particles and contribute expressive content that is associated with the CG. The particle *ja* invokes a fact as CG. *Doch* reactivates a fact that is assumed to already be part of the CG and *wohl* signals that speakers are either not entirely sure about their utterance, e.g. because they only heard of an event but did not witness it, or do not entirely trust the information conveyed by the proposition.

(5) [ja p] establishes or reconfirms the proposition p as part of the common ground (Lindner 1991, Kratzer 1999, Zimmermann 2011).

(6) [doch p] signals that the speaker assumes p not to be activated at the current state in the discourse, because the addressee may have temporarily forgotten about p or the addressee may consider p false (Lindner 1991, Karagjosova 2003, Zimmermann 2011).

(7) [wohl p] expresses a weakened commitment of the speaker to p. [wohl p] has been described as assume(x,p) (Kratzer, 1999, Zimmermann, 2011).

For example, in (2b), the speaker assumes that the hearer knows about the higher potential energy the train will have. In (3b) the speaker signals the addressee that they should already be aware of/believe that there is a TGV from Straßbourg to Stuttgart. And finally, *wohl* in (4b) conveys that the speaker presumes that a matter has been discussed in a certain way, but could not swear to it.

The particles are all highly ambiguous. For example *ja* also just means 'yes', the *doch* can also function as a subordinating conjunction and *wohl* could also be an adjective meaning 'fine, well'. The different usages can generally be disambiguated via syntactic or phonological cues or both. For example the discourse particle *ja* is usually used for acceptance and discourse structuring in its stressed variant and for manipulating certain beliefs in the common ground as illustrated above in its unstressed variant.[2]

[2] Steedman (2014) formulates a pragmatic account of English intonation that is also ultimately based on Stalnaker's CG. The illocutionary force of the German discourse is very similar to that described for English intonation (cf. Schubiger 1965, 1980). Intonation clearly also plays a pragmatic role in German and does interact with the discourse particles. This is an area in need of further work.

Bayer and Obenauer (2011) and Bayer and Trotzke (2015), who work within Minimalism, argue that German discourse particles are minor functional heads which do not project. They concentrate on *denn* 'then', *nur* 'only', *bloß* 'barely' and *schon* 'already'. These have focusing and scopal properties that particles like *ja* or *doch* do not have. As far as we can see, there is no clear (non theory internal) argument for functional head status. We therefore adopt the existing syntactic analysis of the German *ParGram* grammar (Dipper 2003), which treats discourse particles as syntactic adverbs.

3 Formal Pragmatics of Discourse

Stalnaker's (2002) CG model has served as a foundation for most if not all theories of discourse pragmatics. It assumes that all discourse participants in a discourse share a common set of presuppositions, namely, the shared beliefs that all speakers assume to be true for the sake of the conversation. While the main tenets of the model are widely accepted, the details continue to be subject to refinements and many ideas still await formalization.

The most widely accepted extension of Stalnaker's original approach is to use a set-theoretic model that describes the (public) beliefs of the discourse participants and the shared beliefs, i.e., the CG separately. This idea has been pursued by a number of researchers such as Ginzburg (1994), Gunlogson (2002) and Asher and Lascarides (2003). Our particular implementation draws heavily on Gunlogson's formal proposals for the CG.

We use Gunlogson's model since the formalization fits well with the computational and formal scaffolding already put in place by the AKR system within the XLE/XFR grammar development platform (Crouch et al., 2008). Gunlogson's model presupposes a comparatively small number of theorems to generate the different conditions that determine the roles of propositions in the discourse. The model is also well suited to addressing exactly the issues that arise with respect to discourse particles.

In keeping with the literature, we assume that a discourse model can be divided roughly into two parts. One is a collection of beliefs, commonly represented by propositions (section 3.2). The other is a set of rules that coordinates what is happening with these beliefs as the discourse progresses, i.e. a formal understanding of "discourse moves" (section 3.1). The next sections provide more details on this proposal and we illustrate our approach with respect to the discourse particle *doch* 'indeed' (section 3.3).

3.1 Discourse Moves

A formal model of discourse has to: a) collect beliefs that are relevant to the discourse (such as Stalnaker's CG mentioned above); b) record and encode *discourse moves* that describe how certain utterances manipulate the set of relevant beliefs.[3] Some rather well understood discourse moves are, for example, assertion, acceptance and rejection (Walker, 1996). An important part in determining these discourse moves is covered by determining the logical consistency of the discourse. Logical consistency is calculated by taking a new proposition into account in conjunction with the illocutionary force, for example, as conveyed by discourse particles. The new proposition plus the illocutionary force are evaluated against the already existing belief sets and on the basis of this, assertation, acceptance or rejection is calculated.

Note that logical consistency between a new utterance and the CG is not a sufficient condition for acceptance. That is, if an utterance adds nothing new to the CG, it does not automatically convey acceptance of existing belief states in the CG. On the other hand, for rejection, logical inconsistency is a sufficient, but not a necessary condition. Thus, if an utterance is logically inconsistent with the CG, then it is to be classified as a rejection. However, there are other possibilities that also result in rejection which do not require logical inconsistency (Walker 1996).

Working within Segmented Discourse Representation Theory (SDRT), Lascarides and Asher (2009) argue that discourse moves such as accept must include the implicatures engendered by a given utterance. We agree with this and the German discourse particles can be seen as setting up implicatures. Lascarides and Asher's model includes discourse moves and ties these to a more sophisticated analysis of discourse in terms of rhetorical relations. Their model is formalized, but not implemented as part of an NLP application. Embedding the computational work presented in this paper into a more complex discourse model remains to be done.

3.2 Representation of the Common Ground

Our implementation is based on Gunlogson (2002). In this model a discourse participant is associated with a set of public beliefs, so called discourse commitments ($DC_{Speaker/Addressee}$). These have the following definition:

(8) Let DC_A and DC_B be sets of propositions representing the public beliefs of A and B, respectively, where:
a. p is a public belief of A iff 'A believes p' is a mutual belief of A and B
b. p is a public belief of B iff 'B believes p' is a mutual belief of A and B

These two sets together form the same set of propositions as in Stalnaker's notion of the CG. In other words, we can represent Stalnaker's CG by the ordered set $<DC_A, DC_B>$. We can translate the sets introduced above into sets of worlds which are called commitment sets ($cs_{Speaker/Addressee}$), as in (9).

(9) Let a discourse context C be $<cs_A, cs_B>$, where:
a. $cs_A = \{w \in W$: A's public beliefs are all true of w$\}$

[3] From now on, for the sake of illustration, we assume a simple dialog between an speaker A and an addressee B when we talk about discourse.

b. $cs_B = \{w \in W$: B's public beliefs are all true of w$\}$
(Gunlogson, 2002)

The commitment sets allow us to classify propositions in terms of *propositional states*: (i) commitment, (ii) joint commitment (iii) unresolved, (iv) controversial. These propositional states feed into the determination of discourse moves and are crucial for identifying logical consistency within a discourse. The definitions as given by Gunlogson are in (10) and (11).

(10) a. A commitment is any proposition $p \in$ either $cs_{Speaker}$ or $cs_{Addressee}$

b. A joint commitment is a proposition $p \in cs_{Speaker}$ and $p \in cs_{Addressee}$

(11) Commitments may be:

a. unresolved, iff [neither p nor $W\text{-}p \in cs_{Speaker}$] and [$p \in cs_{Addressee}$][4]

b. controversial, iff $W\text{-}p \in cs_{Speaker/Addressee}$ and p is unresolved

A commitment can belong either to the beliefs of one of the discourse participants or to the beliefs shared by the discourse participants, the CG. Commitments can be either unresolved, which means that one of the discourse participants has committed to them, but not the other. A new commitment is typically unresolved, but it can also be controversial. In that case it contradicts the beliefs of the other discourse participant. A joint commitment on the other hand is a belief in the CG.

There are thus three main types of discourse moves: Those that manipulate the speaker's beliefs, those that modify the addressee's beliefs and those that modify the mutually shared beliefs. Furthermore, we can distinguish between assertive discourse moves and interrogative discourse moves.[5]

For an individual x a declarative has the prototypical shape in (12). This basically means that a declarative (a locution in Gunlogson) adds to a given set of beliefs (sets of worlds) those worlds where the declarative is true or rather removes those worlds where the content of the declarative is not true.

(12) $cs_X + S_{decl} = w \in cs_X$: the descriptive content of S_{decl} is true of w

The commitments of the speaker, the commitments of the addressee and the joint commitments can all be updated by a declarative.

3.3 Our Formalization

We illustrate the overall analysis via the discourse particle *doch* 'indeed'. This particle is ambiguous between a contradicting and a reminding reading, see (13) (repeated from (6)). These two situations presuppose different propositional states.

[4] Whereby W-p designates all the worlds in which p is not true.

[5] We concentrate on assertive discourse moves since a comprehensive description of interrogative discourse moves would go beyond the scope of this paper.

The reminding reading is only available in a context where the declarative is either a joint commitment or unresolved, but not controversial. The contradicting reading is only available when the propositional state is controversial.

(13) [doch p] signals that the speaker assumes p not to be activated at the current state in the discourse, because the addressee may have temporarily forgotten about p or the addressee may consider p false (Lindner 1991, Karagjosova 2003, Zimmermann 2011).

Thus, the particle *doch* can be used both for acceptance as well as rejection and serves as a good test case for our implementation. (14) summarizes the architecture underlying our computational implementation. The system stays true to Gunlogson's proposal although we work with slightly different sets of beliefs.

(14)
a. SB (Speaker Belief) = {p: the speaker believes that p is true and the addressee is aware of that}
b. AB (Addressee Belief) = {p: the addressee believes that p is true and the speaker is aware of that}
c. $CG_{S\text{-}A}$ = {p: p is mutually believed by the speaker and the addressee}
$CG_{S\text{-}A} = \{AB \cap SB\}$
d. C (discourse context) = $_{S\text{-}A}$ = $\langle SB, AB, CG_{S\text{-}A} \rangle$

In this formalization the beliefs of discourse participants are sets that contain facts about propositions p in the form ”the speaker believes p”. The speaker is assumed to have full access to the set of propositions in AB, the addressee's beliefs. The beliefs that are shared by both sets, i.e. the intersection, are stored in the $CG_{S\text{-}A}$, the CG (cf. also Caponigro and Sprouse (2007)).

Consider how this plays out with respect to the ambiguous discourse particle *doch* 'indeed'. Let S_{decl}+*doch* be a declarative with the descriptive content of S and the expressive content added by *doch*. There are two situations:

(15)
a. iff $S_{decl+doch}$ is unresolved or a joint commitment in C + $S_{decl+doch}$, then C' = $CG_{S\text{-}A}$ + S_{decl}
b. iff $S_{decl+doch}$ is controversial in $S_{decl+doch}$ then C' = SB + S_{decl}

(15a) covers *doch* in its reactivating or reminding function. In this situation, the speaker asserts the descriptive content of the utterance to the mutually believed commitments, entering it into the CG. The rule in (15b) says that if *doch* occurs in a sentence whose descriptive content is controversial, then the reactivating reading is not available and the sentence only updates the beliefs of the speaker.[6]

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[6]Some sentences with referential expressions cannot be analyzed this way. In that case the descriptive content of the referential needs to be added to the speaker's beliefs. In the following example the referential *Das* may refer to any sort of proposition made earlier in the dialog.

(16) Das glaube ich dir **doch**
that believe I you **indeed**
'I believe you (about this).'

4 Implementation

For the implementation we worked with the existing German ParGram grammar (Dipper, 2003), which already contained a syntactic treatment of German discourse particles.[7] The German grammar also already contained a basic semantic AKR component (Bobrow et al., 2007). The English AKR is fairly extensive and draws on a variety of lexical semantic resources that have been integrated, e.g. WordNet[8]. This remains to be done for the German grammar.

The AKR system is implemented via the XFR rule rewriting system (Crouch et al., 2008), which uses the f-structure as the basis for the construction of a semantic representation. The basic semantic representations are known as *Knowledge Representations*, or KRs, which are then further processed into *Abstract Knowledge Representations* or AKRs that are suitable for inferencing and *Entailment and Contradiction Detection* (ECD) over several facts/utterances.

The AKR for (17) is as in (18). AKRs consist of two components, the *conceptual structure* and the *contextual structure*. The conceptual structure provides facts that are necessary for reasoning such as cardinality and onotological information and it partially represents the predicate-argument structure. Pointers to lexical semantic information are encoded in square brackets. This provides the system a good underlying basis for drawing inferences based on ontological information.

(17) Boris singt.
Boris sings
'Boris is singing.'

(18)

Conceptual Structure:	Contextual Structure:
subconcept(singen:7,[sing-1])	context_head(t, singen:7)
subconcept(Boris:1,[person-1]	top_context(t)
role(Agent,singen:7,Boris:1)	instantiable(singen:7,t)
role(cardinality_restriction,Boris:1,sg)	instantiable(Boris:1,t)

The information that is contained in the conceptual structure remains unchanged by our system. In the next two sections, we describe the modifications of the grammar and the AKR system that work with the contextual structure in order to provide a computational modeling of the CG as described above.

4.1 Syntactic Extensions

By default, the ParGram grammars parse text one sentence at a time. However, the grammars can be modified so as to allow for the processing of multiple sentences within one parse. We modified the German grammar to allow the parsing of small dialogs as in (19), where the speaker is identified at the beginning.

[7] A version of the German grammar can be used interactively via the INESS website: http://clarino.uib.no/iness/xle-web.

[8] https://wordnet.princeton.edu/

(19)	a.	Anna:	Boris	singt.	b.	Clara:	Daniel tanzt.
			Boris	sings			Daniel dances
		'Anna: Boris is singing.'				'Clara: Daniel is dancing.'	

As an illustration, the parse of (19) is given in Figures 1 and 2. The modified grammar uses the category `ROOT` as the top-level node. This expands to `ROOTPunct` and `ROOTmulti`. `ROOTpunct` directly governs a sentence and `ROOTmulti` recursively connects all `ROOTpunct` sentences. The `+SB` indicates a sentence boundary and is necessary for the proper tokenization of the utterances.

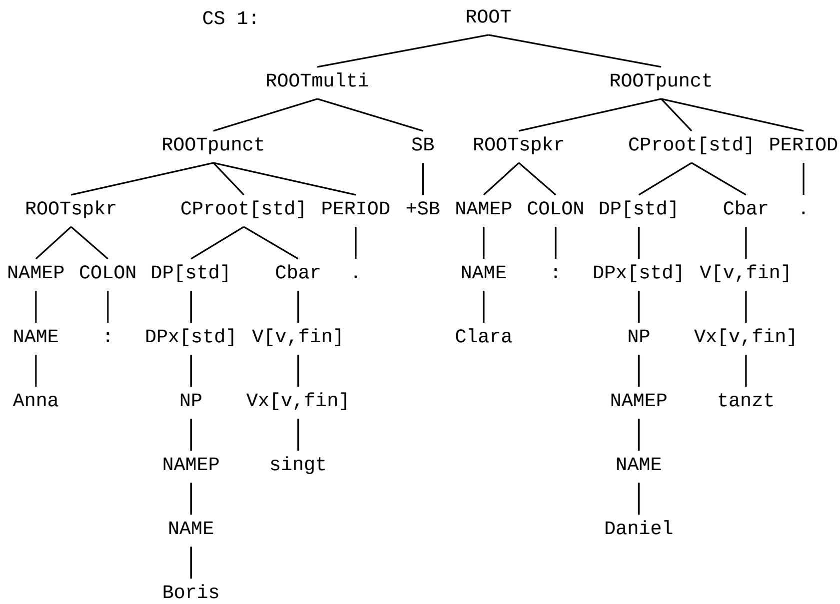

Figure 1: C-structure of the two sentences in (19).

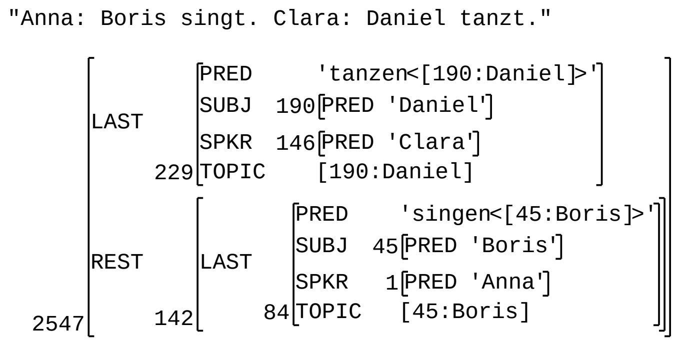

Figure 2: F-structure of the discourse in (19)

The category `ROOTspkr` registers the speaker information. This speaker information is also represented at f-structure under the attributed SPKR. Information about which utterance came first, i.e., the temporal structure of the discoure, is represented at f-structure via a LAST vs. REST partition.[9] The most recent sentence in a discourse is encoded in the outermost f-structure while the first sentence of the discourse is encoded in the innermost f-structure. Although it may seem counterintuitive, this f-structure representation best fits with the existing treatment of contextual information within AKR, as discussed in the next section.[10]

4.2 Pragmatic Extensions

In our implementation, each sentence in a parse is connected to a root node, i.e., `ROOT` in single sentence parses or `ROOTPunct` in multi sentence parses. Speaker information also associates with root nodes. The system requires that each sentence necessarily is directly or indirectly governed by at most one speaker. To explain the importance of this connection it is first necessary to understand the process of rewriting a syntactic structure into a semantic structure.

F-structures as in Figure 2 serve as the basis for the semantic analysis. XLE accesses the f-structure as a list of predicate-argument facts that represent the attribute-value pairs and computes a basic KR. In a KR all facts that make up the semantics of a sentence are connected to some context. These contexts are what are used to model phenomena such as epistemic modality. Contexts are introduced at the root-level of an f-structure. In Crouch and King's (2006) version of the XFR semantics, matrix sentences associate with top-level contexts, i.e., contexts that contain information that is assumed to be true in the actual world. In comparison, embedded contexts with the label `ctx:predicate` are invoked by `COMP`s and `XCOMP`s. Embedded contexts are linked to top level contexts. As a result all contexts in a sentence are rooted in a top-level context. In other words, all contexts are associated with root nodes. Embedded contexts are connected to the top-level context via context-lifting relations, such as `veridical`, induced for example by factive verbs like *know*, or `crel` induced, for example, by *believe*. These relations determine whether the propositional content of a `COMP` or `XCOMP` is true at the top-level context or not.

In our implementation both speaker information and top-level contexts are associated with root nodes. We connect the speaker information directly to the top-level contexts so that facts are associated with `<speaker,context>` pairs instead of only contexts. The semantics then make the facts relative to the speaker's top-level context of the sentence. Unwinding the f-structure information in order to do this via the Prolog logic underlying the construction of the AKRs is most easily achieved via the Rest-Last ordering of utterances shown in Figure 2.

As the revised contextual structure in (20) for (19) shows, the major changes

[9]This was originally introduced in ParGram to allow for the parsing of fragmentary input.

[10]In this paper we assume that one continuous list of utterances associated with one speaker is summed up into one contribution. As pointed out by an anonymous reviewer, it may be necessary to split up the contributions into single sentences and analyze them separately to account better for the scope of certain discourse moves. We leave this for future work.

to the AKR involve changes with respect to instantiability facts. These statements now tell us which pieces of information are believed to be true in which contexts relative to which speakers.

(20) Contextual Structure:
context([Anna]:t)
context([Clara]:t)
context([Clara,Anna]:t)
top_context([Clara,Anna]:t)
instantiable(Boris:7,[Clara,Anna]:t)
instantiable(Daniel:27,[Clara,Anna]:t)
instantiable(singen:13,[Anna]:t)
instantiable(tanzen:34,[Clara]:t)

Other Structure:
discourse_participants([Clara,Anna])

In the original AKR facts are mapped to contexts that roughly represent the actual and possible worlds. In our modified AKR the contextual facts are provided with another dimension, the dimension of speaker commitment. That is, these facts are mapped to those worlds which the speaker associated with them believes to be true. As a result, the instantiability facts tell us exactly who believes what.[11]

The remainder of the AKR construction makes sure that these facts are only true in the right conceptual environment (e.g. predicate argument structure) via the conceptual structure. Overall, the changes to the existing AKR component were rather minimal since many of the prerequisites for a modeling of the CG in discourses were already in place.

In conclusion, out implementation allows us to model the set-theoretic assumptions of Gunlogson's discourse models with AKRs. Facts can be instantiable with respect to (i) the speaker, (ii) the addressee, (iii) the speaker and the addressee and the context they are associated with respectively.

4.3 Modeling the Common Ground — Discourse Moves

The pragmatic parser relies heavily on the Entailment and Contradiction Detection (ECD) that is part of the XLE/XFR platform and that was originally used as part of a Q&A system that the original AKR was designed for. In the original system, the ECD operates on a query that is matched to a set of stored facts and detects whether a stored fact matches the query. The match could be a direct match or be the result of a chain of inferencing. For example given the stored information that

[11]We assume entities denoted by proper names to be presupposed. That is, each discourse participant accepts the existence of an individual denoted by a proper name and can judge utterances made about that individual. As a reviewer points, out, this assumption is open to debate. We leave this for future work. Note also, that while the industrial strength version of the English grammar did incorporate a component for anaphora resolution, we do not have access to such anaphora resolution for the German grammar. Thus, we make the simplifying assumption for now that a proper name always denotes the same entity. This is the case for both speaker information and proper names in the discourse. When treating larger diaologs, we can employ unique indices instead.

a boy rode a bicycle, the system can infer that the answer to the query *Did a child ride a bicycle?* is “yes” via the information that a boy is a subconcept of *child*.

In our system, we crucially rely on the ECD to determine the type of discourse move a given utterance represents. This classification in turn steers the dynamic update of the CG. As in the original Q&A task, our implementation aligns a set of stored facts, namely the existing belief states, with a query. This “query” is the AKR representing the newest contribution to a dialog. The ECD checks whether it is possible to remove all query facts via a system that unifies passage and query. If unification is not possible, the system checks whether query and passage logically contradict each other and if so flags the fact that is responsible as contradictory.

The ECD thus returns one of three possible answers: `YES` (corresponding alignment) in case of entailment, `NO` in case of contradiction and `UNKOWN` otherwise. Each new utterance is assigned one of the three propositional states shown in (21), depending on the result of the ECD query. The ECD result triggers a specific set of rules for rewriting the CG as illustrated by prototypical rules in (21). The antecedent of the rules in (21) illustrates the shape of the facts in the query (i.e. the new contribution), while the consequent denotes the shape of the fact in the AKR of the complete discourse. The rules are simplified for the sake of illustration.[12]

(21) commitment – default: `instantiable(fact,[speaker:t)])`

joint commitment:	ECD returns `YES`
	`instantiable(fact,[speaker]),`
	`instantiable(fact,[addressee])` ==>
	`instantiable(fact,[speaker,`
	`addressee]:t)`

unresolved:	ECD returns `UNKNOWN` `instantiable(fact,[speaker:t])` ==> `instantiable(fact,[speaker:t])`

controversial:	ECD returns `NO`
	`instantiable(fact,[speaker:t])` ==>
	`instantiable(controversial,fact,`
	`[speaker:t])`

Based on the propositional states the system can make hypotheses about the intended discourse moves, i.e., whether the speaker intends to accept or reject previously uttered information. Acceptance leads to a simple update of the belief states. The speaker accepts a proposition as joint commitment. Rejection is more complex. In principle a new update to the CG that is controversial with respect to the previous CG will most likely indicate a rejection move. For now, the system always concludes a rejection move if it detects a controversial propositional

[12]The rules are also applied in the same fashion to uninstantiable facts. Also note that the unresolved rule actually does nothing and is listed here only for purposes of illustration. In the implementation the system simply does nothing in this case.

state.[13] The facts that belong to the new update are than flagged as such. The flag is necessary to guarantee the integrity of the AKR, since otherwise we would have contradicting facts in the AKR representing the discourse structure. This in turn would lead to obvious problems for the ECD.

Discourse particles and similar phenomena further affect how information is treated by the rewrite rules. Recall that *ja* 'yes' and *doch* 'indeed' both may add facts to the CG. Rules ensuring this pragmatic inferencing triggered by discourse particles are applied after the ECD check. The rules belong to the set of rules that combine the previous CG with the information added by the new discourse contribution introduced in (21). This means we first check the "at-issue" conent of the new proposition and then in a further step parse its expressive content as part of updating the CG. The following sequence of rules are applied for each new utterance to be added to the CG: (i) load the existing CG-AKR; (ii) create a "query" AKR from the new discourse contribution; (iii) run ECD rules; (iv) run rule set for combining CG-AKR and the query AKR based on ECD information and other pragmatic cues such as those triggered by discourse particles.

4.4 Pragmatic Parsing of Discourse Particles

In this section, we discuss our treatment of *ja* 'yes', *doch* 'indeed' and *wohl* 'presumably'. They each present an different test case. The discourse particle *ja* represents a case in which the right reading of the particle needs to be identified by a non-pragmatic module. The particle *doch* must be disambiguated as part of the pragmatic parsing and *wohl* illustrates how the system deals with representing different layers of commitment.

For the sake of illustration, we always assume direct temporal precedence of the relevant content. In other words, as before, we assume very small segments of discourse consisting of an utterance and a response to that utterance.

4.4.1 The Particle *ja*

The role of *ja* in discourse is two-fold if we follow the analysis of Zimmermann (2011). Either, it is a discourse-structuring particle that marks acceptance as well as rejection (stressed *ja*), or it is a discourse particle that marks that an utterance should be in the CG (unstressed *ja*, e.g. in (2)). In other words: an utterance made

[13] However, the time span between the update and the contradicting fact in the previous discourse needs to be taken into consideration. The current implementation is not time span sensitive since we have only implemented analyses of very short discourse pieces. The system architecture has three states: *direct temporal precedence* referring to the information in the CG that was changed by the previous update; *temporal precedence* for all information that lies beyond that point in the past and *disconnected precedence*. The latter is information that happened in a previous discourse segment which is temporally independent from the current discourse. The beliefs that fall under the notion *temporally independent* roughly include everything that is not part of the currently analyzed discourse, e.g. common general knowledge and possibly information from a previous discourse. I.e. all facts that the discourse participants mutually believe to be true before the start of the current dialog.

with unstressed *ja* either adds its content to the CG or repeats something that is already in the CG. These two readings can be disambiguated primarily by phonological cues (stressed vs. unstressed). Given the first option, we can disambiguate between acceptance and rejection via a logical consistency check and thus determine the discourse move the speaker intended.

The repetition reading is only available when the conveyed content is not controversial. The expressive content that is added to the meaning of a sentence by the particle *ja* asserts the semantic content of the sentence to the CG. This means that if the conveyed content so far has the status of being unresolved or is already registered as a commitment, it is updated to a joint commitment in the belief states. In this sense, the stressed *ja* and the unstressed *ja* overlap in meaning. An assertive discourse move can still be rejected later on, as illustrated in (22).[14]

(22) Context of dialog: Conversation between two people who talk about the animal they are looking at in the petting zoo.

Speaker: Das ist **ja** ein Kaninchen.
That is **yes** a rabbit
'This is a rabbit (as I want you to know).'

Addressee: Ich glaube, das ist ein Hase.
I think that is a hare
'I think this is a hare.'

The system captures the intuition that both the stressed and the unstressed *ja* add something to update the CG and that *ja* can also be used for the purpose of rejection. The various readings of *ja* must be identified via a combination of syntactic and phonological cues.

4.4.2 The Particle *doch*

The discourse particle *doch* has two different readings. A rejection reading and a (re)activation reading (Zimmermann 2011, Karagjosova 2003). Both readings can be inferred by the state of the *doch*-proposition in the CG. Generally, the rejection reading occurs whenever there is logical inconsistency with respect to the CG or the beliefs of the addressee. This normally occurs as direct consequence of the last discourse moves. Thus, direct temporal precedence, as we presuppose in this section, plays a factor in analyzing *doch* as indicator for rejection.[15]

The activation reading of *doch* applies if *doch* + proposition is so far unresolved in the CG. This means the ECD returns neither a contradiction nor a confirmation. The rewrite rules that modify the CG then "activate" the proposition and make it part of the CG. We illustrate how this works in our system via the short dialog

[14] There is also a third reading of *ja*, where *ja* is a sign of being impressed or surprised. This reading is in principle also available in (22).

[15] *doch* may also appear as the only word in an utterance. In this case, it conveys rejection. When *ja* is uttered by itself, in contrast, it conveys acceptance.

in (23), where Anna makes an assertion that is not directly contradicted by Clara. Rather, she uses *doch* to (re)activate the information in the CG that Boris also dances. The contextual information in the AKR in (24) records the belief states of the individual participants and of the CG (which in this case is what both Anna and Clara believe).

(23) a. Anna: Boris singt.
   Boris sings
   'Anna: Boris sings.'

 b. Clara: Boris tanzt doch.
   Boris dances indeed
   'Clara: Boris dances (as you should know).'

(24) a. **Common Ground: Anna: Boris singt.**

Contextual Structure:
context([Anna]:t)
context_head([Anna]:t,singen:13)
top_context([Anna]:t)
instantiable(Boris:7,[Anna]:t)
instantiable(singen:13,[Anna]:t)

Other Structure:
discourse_participants([Anna])

 b. **New contribution: Clara: Boris tanzt doch.**

Contextual Structure:
context([Clara]:t)
context_head([Clara]:t,tanzen:13)
top_context([Clara]:t)
instantiable(Boris:7,[Clara]:t)
instantiable(tanzen:13,[Clara]:t)

Other Structure:
discourse_participants([Clara])

 c. **Result of ECD:**
proposition state: new information;
discourse move: assertion

 d. **Update/Rewriting in accordance with ECD:**
Anna: Boris singt. Clara: Boris tanzt doch.

Contextual Structure:
context([Anna]:t)
context([Clara]:t)
context([Clara,Anna]:t)
top_context([Clara,Anna]:t)
instantiable(Boris:7,[Clara,Anna]:t)
instantiable(singen:13,[Anna]:t)
instantiable(tanzen:33,[Clara,Anna]:t)

Other Structure:
discourse_participants([Clara,Anna])

Information in the CG is matched with a new contribution. The Query Match detects no contradiction and the result of the ECD analysis is that the new contribution is classified as the discourse move of assertion due to the contribution of the discourse particle *doch*. This triggers an update of the CG as shown in (24d).

4.4.3 The Particle *wohl*

The discourse particle *wohl* works differently than *ja* 'yes' and *doch* 'indeed' in that *wohl* expresses a weakened commitment to a proposition. In our system, we allow for two forms of weakened commitment: (1) temporally weakened, if there is a large temporal distance between the addition of the proposition to the CG and the utterance *wohl* + p; (ii) semantically weakened if the information is connected to an embedded context instead of the top level context.

Recall that the AKR already includes a modeling of embedded propositions in terms of allowing for non-veridical embedded propositions for verbs such as *believe* (vs. *know*). This is achieved via the `context` predicate in the AKR in conjunction with context-lifting relations (`veridical, crel`), see section 4.4. We adapt the existing AKR treatment of embedded propositions to *wohl*.

All of the pragmatic parsing steps also apply to *wohl*. The existing (if any) CG-AKR is loaded. A "query" is formulated from the new discourse contribution and the "at-issue" content is checked for contradictions. The ECD component is then applied and new information is integrated into the CG as appropriate.

Consider the dialog in (25), where the addressee offers a conjecture as to what the cause of the loud music might be (Boris is dancing). The *wohl* conveys that the addressee is making a conjecture, not stating a fact.

(25) Anna: Very loud music is playing next door.
Clara: Boris tanzt **wohl**.
Boris dances **presumably**
'Presumably, Boris is dancing.'

The parsing of the discourse particle *wohl* induces an operation similar to that of *ja* and *doch*, but it updates an embedded context instead of the top-level context, as *ja* and *doch* do. This models the existing analysis of *wohl* + proposition as `assume(proposition)` (Zimmermann, 2011).

As shown in (26), the embedded context and the top-level context are connected by the context relation that indicates embedding of the context `ctx` under the top-level context `t`. The context `ctx` represents a different level of commitment of p, namely `assume(speaker,p)`, compared to the context `t` which expresses something like `know(speaker,p)`.

(26) **New contribution: Clara: Boris tanzt wohl.**
Contextual Structure:
context([Clara]:t)
context([Clara]:ctx(tanzen:32))
context_head([Clara]:t,wohl:18)
top_context([Clara]:t)
context_relation([Clara]:t,[Clara]:ctx(tanzen:32),wohl:18))
instantiable(Boris:26,[Clara]:ctx(tanzen:32))
instantiable(Boris:26,[Clara]:t)
instantiable(tanzen:32,[Clara]:ctx(tanzen:32))

The system treats the relation asserted in the AKR as a `crel` relation. This means the speaker has no credible source that the information related to the embedded context is true in the actual world. As part of the CG update after the ECD step, this context is updated for all of the discourse participants with the facts comprised in *wohl* + proposition. The effect is that the proposition modified by *wohl* enters the CG of all the discourse participants, but with the status of an assumption.

Another condition for this analysis is that *wohl* + proposition has the status of being unresolved so far in the beliefs of at least the speaker. If this is not the case, for example, if the proposition represents a commitment of one of the discourse participants, then that person's belief set does not change.

4.5 Summary of Implementation

We have shown how to represent belief states of discourse participants via AKRs and how to keep track of individual and CG knowledge. We have also shown how discourse particles contribute information pertinent to the CG and in terms of the discourse moves of a speaker.

The subtle differences between *ja*, *doch* and *wohl* are captured by our analysis. As can be seen in (27), there is some overlap in the meaning of these discourse particles, but our analysis takes into account the slight nuances by which they alter the pragmatic content of an utterance.

(27)	unstressed *ja*	if for *ja* + p, p is either unresolved or a joint commitment ⟶ p is added to the CG.
	doch	if for *doch* + p, p is either unresolved or a weakened commitment ⟶ p is added to the CG.
	wohl	if for *wohl* + p, p is either unresolved or a weakened commitment ⟶ p is added as weakened commitment to the CG.

The analysis is implemented via XFR rewrite rules. For each contribution to the CG the system calculates the AKR of the new utterance and determines its propositional state with respect to the AKR representing the CG. This is achieved by using the ECD system.

The system also calculates discourse moves and flags them if necessary. The flagging is necessary, for example, for discourse moves of a controversial nature that may lead to rejection.[16] Controversial moves in a discourse participant's AKR are rewritten as soon as a new proposition made by the discourse participant contradicts it and this proposition is logically consistent with the CG. This means that the discourse participant revises their own beliefs and accepts the beliefs of the

[16] It is also necessary for questions, for example, which do not add anything to the CG. There may be other discourse moves that require special flags but this is left for future work. This would mainly concern discourse moves that do not serve to structure or to update the CG.

other discourse participant. As a result this requires the ECD to be sensitive to the propositional state and flags such as `controversial`. Ultimately, no information about discourse moves surfaces in the AKR. The AKR only encodes information about the beliefs of the discourse participants.

5 Conclusion and Outlook

Our analysis and implementation is capable of capturing the finely nuanced meanings of the discourse particles and uses these to organize the beliefs in the discourse structure. Our paper presents a formal pragmatic approach for analyzing discourse particles. Specifically, we employed a discourse model based on set-theoretic notions devised by Gunlogson (2002). For this discourse model we described means to identify some basic discourse moves in accordance with Walker (1996). Finally, we established the connection between Gunlogson's model, discourse moves and discourse particles. In other words, we elaborated on how discourse particles operate on the CG in interaction with discourse moves.

We illustrated the workings of our pragmatic parser with respect to the German discourse particles *ja*, *doch* and *wohl*. Our analysis has a strong orientation towards natural language processing tasks and we implemented our analysis by means of the XLE/XFR grammar development platform. We used the German ParGram grammar as a basis, augmenting it to deal with multi-sentence discourses and extending the existing AKR semantic component to register speaker belief states, calculate discourse moves and keep track of information in the CG. We found that the AKR was already set up well for our task as there are parallels between the Q&A PARC bridge system the AKR was originally designed for (Bobrow et al., 2007) and the entailment and contradiction detection that is needed for modelling CG. The overall system is modular and can be extended in several different ways to apply to broader research questions than the ones pursued here.

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