Chapter 29

Grammar in dialogue

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"It takes two to make a truth."
Austin (1950: 124, footnote 1)

This chapter portrays some phenomena, technical developments and discussions that are pertinent to analysing natural language use in face-to-face interaction from the perspective of HPSG and closely related frameworks. The use of the CONTEXT attribute in order to cover basic pragmatic meaning aspects is sketched. With regard to the notion of common ground, it is argued how to complement CONTEXT by a dynamic update semantics. Furthermore, this chapter discusses challenges posed by dialogue data such as clarification requests to constrained-based, model-theoretic grammars. Responses to these challenges in terms of a type-theoretical underpinning (TTR, a Type Theory with Records) of both the semantic theory and the grammar formalism are reviewed. Finally, the dialogue theory *KoS* that emerged in this way from work in HPSG is sketched.

1 Introduction

The archaeologists Ann Wesley and Ray Jones are working in an excavation hole, and Ray Jones is looking at the excavation map. Suddenly, Ray discovers a feature

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that catches his attention. He turns to his colleague Ann and initiates the following exchange (the example is slightly modified from Goodwin 2003: 222; underlined text is used to indicate overlap, italic comments in double round brackets are used to describe non-verbal actions, numbers in brackets quantify the duration of pauses):

(1)

1.	RAY:	Doctor Wesley?
2.		(0.7) ((*Ann turns and walks towards Ray*))
3.	ANN:	EHHH HEHH ((*Cough*))
4.		Yes Mister Jones.
5.	RAY:	I was gonna see:
6.	ANN:	°Eh heh huh huh
7.		°eh heh <u>huh huh</u>
8.	RAY:	<u>Uh::m</u>,
9.	ANN:	Ha huh HHHuh
10.	RAY:	((*Points with trowel to an item on the map*)) I think I finally found **this** feature ((*looks away from map towards a location in the surrounding*))
11.		(0.8) Cause I: hit the **nail**
12.		((*Ann looks at map, Ray looks at Ann, Ann looks at Ray*))

Contrast the archaeological dialogue from (1) with a third person perspective text on a related topic. In a recent archaeology paper, the excavation of gallery grave Falköping stad 5 is described, among others (Blank et al. 2018: 4):

> During excavation the grave was divided in different sections and layers and the finds were documented in these units. The bone material lacking stratographic and spatial information derives from the top layer [...]. Both the antechamber and the chamber contained artefacts as well as human and animal skeletal remains, although most of the material was found in the chamber.

The differences between the archaeological dialogue and the paper are obvious and concern roughly the levels of *medium* (spoken vs. written), *situatedness* (degree of context dependence), *processing speed* (online vs. offline) and *standardisation* (compliance with standard language norms) (Klein 1985). Attributing differences between dialogue and text simply to the medium (i.e. spoken vs. written) is tempting but insufficient. The corresponding characterising features seem to form a continuum, as discussed under the terms *conceptual orality* and *conceptual literacy* in the (mainly German-speaking) literature for some time (Koch &

Oesterreicher 1985). For example, much chat communication, although realised by written inscriptions, exhibits many traits of (conceptually) spoken communication, as investigated, for instance, by means of chat corpora (Beißwenger et al. 2012). Face-to-face dialogue stands out due to a high degree of context dependence manifested in shared attention (Tomasello 1998; see also turns 2 and 12 between Ann and Ray), non-verbal actions such as hand and arm gestures (Kendon 2004; McNeill 2000; turn 10; cf. Lücking 2019, Chapter 31 of this volume for a brief overview of non-verbal communication means), disfluencies (Ginzburg et al. 2014; turns 5 to 8), non-sentential utterances (Fernández & Ginzburg 2002; Fernández et al. 2007; turns 1, 4, and 5), laughter (Ginzburg et al. 2015; turn 9), shared knowledge of interlocutors (Clark et al. 1983; turns 10–12), turn-taking (Sacks et al. 1974; Heldner & Edlund 2010; Levinson & Torreira 2015; e.g. question-answering in turns 1 and 4) and indirect reference (turn 10, where Ray points to an item on the map but refers to an archaeological artefact in the excavation hole). Note that such instances of deferred reference (Nunberg 1993) in situated communication actually differ from bridging anaphora (Clark 1975) in written texts, although they seem to be closely related at first glance. Bridging is a kind of indirect reference, too, where a definite noun phrase refers back to an antecedent entity which is not given in a strict sense, like *the goalkeeper* in *I watched the football match yesterday. The goalkeeper did an amazing save in overtime*. However, bridging NPs does not give rise to an index or demonstratum, which is the "deferring base" in case of indirect deixis (cf. Lücking 2018).

Since these phenomena are usually abstracted away from the linguistic knowledge encoded by a grammar, linguistics is said to exhibit a "written language bias" (Linell 2005). In fact, many of the phenomena exemplified above provide serious challenges to current linguistic theory, as has been argued by Ginzburg (2012), Ginzburg & Poesio (2016) and Kempson et al. (2016). So the question is: how serious is this bias? Is there a single language system with two modes, written and spoken (but obeying the qualifications we made above with respect to conceptual orality and literacy)? Or do written and spoken communication even realise different language systems? Responses can be given from different standpoints. When the competence/performance distinction was proposed (Chomsky 1965), one could claim that linguistic knowledge is more purely realised by the high degree of standardisation manifested in written text, while speech is more likely to be affected by features attributed to performance (e.g. processing issues such as short term memory limitations or impaired production/perception). Once one attaches more importance to dialogical phenomena, one can also claim that there is a single, basic language system underlying written and spoken communication which bifurcates only in some cases, with interactivity and deixis being salient examples (such a position is delineated but not embraced by Klein 1985; in fact, Klein remains neutral on this issue). Some even claim that "grammar is a system that characterizes talk in interaction" (Ginzburg & Poesio 2016: 1).[1] This position is strengthened by the primacy of spoken language in both ontogenetic and language acquisition areas (on acquisition see Ginzburg 2019, Chapter 26 of this volume).

Advances in dialogue semantics are compatible with the latter two positions, but their ramifications are inconsistent with the traditional competence/performance distinction (Ginzburg & Poesio 2016; Kempson et al. 2016). Beyond investigating phenomena which are especially related to people engaging in face-to-face interaction, dialogue semantics contributes to the theoretical (re)consideration of the linguistic competence that grammars encode. Some of the challenges posed by dialogue for the notion of linguistic knowledge – exemplified by non-sentential utterances such as clarification questions and reprise fragments (Fernández & Ginzburg 2002; Fernández et al. 2007) – are also main actors in arguing *against* doing semantics within a unification-based framework (like Pollard & Sag 1987) and have implications for doing semantics in constraint-based frameworks (like Pollard & Sag 1994; see Section 3.1 below). In light of this, the relevant arguments are briefly reviewed below. As a consequence, we show how dialogue phenomena can be captured with a framework that leaves "classical" HPSG (i.e. HPSG as documented throughout this handbook). To this end, TTR (a Type Theory with Records) is introduced in Section 3.3. TTR is a strong competitor to other formalisms since it provides an account of semantics that covers dialogue phenomena from the outset. TTR also allows for "emulating" an HPSG kind of grammar, giving rise to a unified home for sign-based SYNSEM interfaces bridging to dialogue gameboards (covered in Section 4). To begin with, however, we give a brief historical review of pragmatics within HPSG.

[1] The sign structure used in HPSG is partly motivated by the bilateral notion of sign of de Saussure. In this respect it is interesting to note that also de Saussure advocated the primacy of spoken language:

> Sprache und Schrift sind zwei verschiedene Systeme von Zeichen; das letztere besteht nur zu dem Zweck, um das erstere darzustellen. Nicht die Verknüpfung von geschriebenem und gesprochenem Wort ist Gegenstand der Sprachwissenschaft, sondern nur das letztere, das gesprochene Wort allein ist ihr Objekt. (de Saussure 2001: 28)
> (*Language and writing are two different systems of signs; the latter exists only for the purpose of representing the former. It is not the combination of the written and the spoken word that is the subject of linguistics, but only the latter, the spoken word alone, is its object.*)

In this respect, de Saussure acts as an early exponent *against* any written language bias.

2 From CONTEXT to update semantics for dialogue

HPSG's interface to pragmatics is the CONTEXT attribute. The CONTEXT attribute accommodates contextual constraints that have to be fulfilled in order for an expression to be used appropriately or felicitously (Austin 1962), to use a term from speech act theory (Pollard & Sag 1994: 27). The CONTEXT attribute has been used and extended to model the content of indexical and pronominal expressions (see Section 2.1), information packaging (Section 2.2) and shared background assumptions concerning standard meanings (Section 2.3). A further step from such pragmatic phenomena to dialogue semantics is achieved by making signs encode their dialogue context, leading to an architectural revision in terms of *update semantics* (see Section 2.4).

2.1 C-INDS and BACKGROUND

The CONTEXT attribute introduces two sub-attributes, CONTEXTUAL-INDICES (C-INDS) and BACKGROUND. The C-INDS attribute values provide pointers to circumstantial features of the utterance situation such as speaker, addressee and time and location of speaking. Within the BACKGROUND attribute, assumptions such as presuppositions or conventional implicatures are expressed in terms of *psoas*, *parameterised state of affairs* (see Section 3.2 for some alternative semantic representation formats). For instance, it is part of the background information of the pronoun *she* of the "natural gender language" English that its referent is female (this does not hold for "grammatical gender languages" like French or German). In the HPSG format of Pollard & Sag (1994: 20), this constraint is expressed as in (2), where "HEAD *noun*[CASE *nom*]" abbreviates a head structure of type *noun* which bears a case attribute with value *nom* (nominative):

(2)
$$\begin{bmatrix} \textit{word} & \\ \text{PHON} & \langle \textit{she} \rangle \\ \text{SYNSEM} & \begin{bmatrix} \textit{synsem} & \\ \text{LOCAL} & \begin{bmatrix} \textit{local} & \\ \text{CATEGORY} & \begin{bmatrix} \textit{cat} & \\ \text{HEAD} & \textit{noun}[\text{CASE } \textit{nom}] \\ \text{SUBCAT} & \langle\ \rangle \end{bmatrix} \\ \text{CONTENT} & \begin{bmatrix} \textit{ppro} & \\ \text{INDEX} & \boxed{1} \begin{bmatrix} \textit{ref} & \\ \text{PER} & \textit{3rd} \\ \text{NUM} & \textit{sing} \\ \text{GEN} & \textit{fem} \end{bmatrix} \\ \text{RESTR} & \{\} \end{bmatrix} \\ \text{CONTEXT} & \begin{bmatrix} \textit{context} & \\ \text{BACKGROUND} & \left\{ \begin{bmatrix} \textit{psoa} & \\ \text{RELN} & \textit{female} \\ \text{INST} & \boxed{1} \end{bmatrix} \right\} \end{bmatrix} \end{bmatrix} \end{bmatrix} \end{bmatrix}$$

The CONTENT value is of type *ppro* (*personal-pronoun*), which is related to the NP type (+p, −a) from *Government and Binding* theory (Chomsky 1981) and interacts with HPSG's binding theory (see Branco 2019, Chapter 21 of this volume; see also Wechsler 2019, Chapter 6 of this volume). The CONTENT/CONTEXT description in (2) claims that whatever the referent of the pronoun is, it has to be female.

The contextual indices that figure as values for the C-INDS attribute provide semantic values for indexical expressions. For instance, the referential meaning of the singular first person pronoun *I* is obtained by identifying the semantic index with the contextual index "speaker".[2] This use of CONTEXT is illustrated in (3), which is part of the lexical entry of *I*.

[2] There are also indirect uses of *I*, where identification with the circumstantial speaker role would lead to wrong results. An example is the following:

Here it is the truck, not the speaker, or rather the author of the note, that is for rent. Such examples of the German cognate of "I", namely *Ich*, are collected and discussed in Kratzer (1978).

(3)
$$
\begin{bmatrix}
\textit{word} & \\
\textsc{phon} & \langle\, \textit{i} \,\rangle \\
\textsc{synsem} & \begin{bmatrix}
\textit{synsem} & \\
\textsc{local} & \begin{bmatrix}
\textit{local} & \\
\textsc{content} & \begin{bmatrix}
\textit{ppro} & \\
\textsc{index} & \boxed{1} \begin{bmatrix} \textit{ref} & \\ \textsc{ref} & \textit{1st} \\ \textsc{num} & \textit{sing} \end{bmatrix} \\
\textsc{restr} & \{\}
\end{bmatrix} \\
\textsc{context} & \begin{bmatrix}
\textit{context} & \\
\textsc{c-inds} & \begin{bmatrix} \textit{psoa} & \\ \textsc{spkr} & \boxed{1} \end{bmatrix}
\end{bmatrix}
\end{bmatrix}
\end{bmatrix}
\end{bmatrix}
$$

Inasmuch as the contextual anchors (see Barwise & Perry 1983: 72–73 or Devlin 1991: 52–63 on anchors in Situation Semantics) indicated by a boxed notation from (3) provide a semantic value for the speaker in a directly referential manner (see Marcus 1961 and Kripke 1980 on the notion of direct reference with regard to proper names), they also provide semantic values for the addressee (figuring in the content of *you*) as well as the time (*now*) and the place (*here*) of speaking.[3] Hence, the CONTEXT attribute accounts for the standard indexical expressions and provides a present tense marker needed for a semantics of tenses along the lines of *Discourse Representation Theory* (Kamp & Reyle 1993; see Partee 1973 on the preeminent role of an indexical time point). We will not discuss this issue further here (see Van Eynde 1998; 2000, Bonami 2002 and Costa & Branco 2012 for HPSG work on tense and aspect), but move on to briefly recapture other phenomena usually ascribed to pragmatics (see also Kathol et al. 2011: Section 5.2).

2.2 Information structure

Focus, expressed by sentence accent in English, can be used for information packaging that may lead to truth-conditional differences even when the surface structures (i.e. strings; see Section 1 on a brief juxtaposition of spoken and written language) are the same (Halliday 1967). An example is given in (4), taken from Krifka (2008: 246), where capitalisation indicates main accent and subscript "F" labels the focused constituent (see also Wasow 2019, Chapter 27 of this volume on incremental processing also with respect to aspects of information structure):

[3] Of these, in fact, only the speaker is straightforwardly given by the context; all others can potentially involve complex inference.

(4) a. John only showed Mary [the PICTures]$_F$.
b. John only showed [MARY]$_F$ the pictures.

An analysis of examples like (4) draws on an interplay of phonology, semantics, pragmatics and constituency and hence emphasises in particular the advantages of the *fractal* architecture of HPSG (Johnson & Lappin 1999). HPSG has the fractal property since information about phonetic, syntactic and semantic aspects is present in every sign, from words to phrases and clauses (Pollard 1997: 5) – see also Kubota (2019), Chapter 33 of this volume, Borsley & Müller (2019), Chapter 32 of this volume, Müller (2019), Chapter 36 of this volume, Wechsler & Asudeh (2019), Chapter 34 of this volume and Hudson (2019), Chapter 35 of this volume for a comparison of HPSG to other grammar theories; a benchmark source is Müller (2016).

At the core of information structure is a distinction between *given* and *new* information. Accordingly, information structure is often explicated in terms of dynamic semantics (ranging from *File Change Semantics* by Heim 2002 and *Discourse Representation Theory* by Kamp & Reyle 1993 to information state update semantics proper by Traum & Larsson 2003) – see for instance Krifka (2008) or Vallduví (2016) for a discussion and distinction of various notions bound up with information structure such as *focus*, *topic*, *ground* and *comment* seen from the perspective of dialogue content and dialogue management. The most influential approach to information structure within HPSG is that of Engdahl & Vallduví (1996). Here a distinction between *focus*, that is, new information, and *ground*, the given information, is made (Engdahl & Vallduví 1996: 3). The *ground* is further bifurcated into LINK and TAIL, which connect to the preceding discourse in different ways (basically, the link corresponds to a discourse referent or file, and the tail corresponds to a predication which is already subsumed by the interlocutors' information states). The information packaging of the content values of a sentence is driven by phonetic information in terms of A-accent and B-accent (Jackendoff 1972: Chapter 6), where "A-stressed" constituents are coindexed with FOCUS elements and "B-stressed" are coindexed with LINK elements – see also Kuthy (2019), Chapter 24 of this volume. The CONTEXT extension for information structure on this account is given in (5):

(5)
$$\begin{bmatrix} \textit{context} & \\ \text{C-INDS} & [\,] \\ \text{BACKGR} & \{\} \\ \text{INFO-STR} & \begin{bmatrix} \textit{info-struc} & \\ \text{FOCUS} & \textit{set(content)} \\ \text{GROUND} & \begin{bmatrix} \textit{ground} & \\ \text{LINK} & \textit{set(content)} \\ \text{TAIL} & \textit{set(content)} \end{bmatrix} \end{bmatrix} \end{bmatrix}$$

Part of the analysis of the sample sentences from (4) is that in (4a), the CONTENT value of the indirect object NP *the pictures* is the focused constituent, while it is the CONTENT value of the direct object NP *Mary* in (4b). The FOCUS-LINK-TAIL approach works via structure sharing: the values of FOCUS, LINK and TAIL get instantiated by whatever means the language under consideration uses in order to tie up information packages (whether syntactic, phonological or something else besides). If prosodic information is utilised for signalling information structure, a grammar has to account for the fact that prosodic constituency is not isomorphic to syntactic constituency, that is, prosodic structures cannot be built up in parallel to syntactic trees. Within HPSG, the approach to *prosodic constituency* of Klein (2000) employs *metrical trees* independent from syntactic trees, but grammatic composition remains syntax-driven. The latter assumption is given up in the work of Haji-Abdolhosseini (2003). Starting from Klein's work, an architecture is developed that generalises over prosody-syntax mismatches: on this account, syntax, phonology and information structure are parallel features of a common list of domain objects (usually the inflected word forms). Information structure realised by prosodic stress is also part of the speech-gesture interfaces within multimodal extensions of HPSG (cf. Lücking 2019, Chapter 31 of this volume).

2.3 Mutual beliefs

A strictly pragmatic view on meaning and reference is presented by Green (1996). Green provides a CONTEXT extension for the view that restrictions on the index actually are background assumptions concerning standard uses of referential expressions. One of the underlying observations is that people can, for example, use the word *dog* to refer to, say, toy dogs or even, given appropriate context information, to a remote control (we will come back to this example shortly). The fact that the word *dog* can be used without further ado successfully to refer to instances of the subspecies *Canis lupus familiaris*[4] is due to shared assumptions

[4] Green (1996: Example (73)) actually restricts the standard use of *dog* to the family *Canis* (regiven in our example (6)), which seems to be too permissive. The *Canis* family also include

about the standard meaning of *dog*. Green represents this account in terms of mutual beliefs between EXPERIENCER and STANDARD as part of the background condition of the CONTEXT of referential NPs. Drawing on work by Cohen & Levesque (1990), *mutually-believe* is a recursive relation such that the experiencer believes a proposition, believes that the standard believes the proposition too, believes that the standard believes that the experiencer believes the proposition, and so on. When a proposition is mutually believed within a speech community, it is *normally believed.* The semantic part of the lexical structure of *dog* is given in (6). The analysis of proper names is pursued in a similar manner, amounting to the requirement that for a successful use of a proper name, the interlocutors have to know that the intended referent of this name actually bears the name in question.

(6)
$$\left[\begin{array}{ll}
\textit{word} & \\
\text{PHON} & \langle \textit{ dog } \rangle \\
\text{CONTENT} & \left[\begin{array}{ll} \textit{ref} & \\ \text{INDEX} & \boxed{1} \end{array}\right] \\
\text{CONTEXT} & \left[\begin{array}{ll}
\textit{context} & \\
\text{C-INDS} & \left[\begin{array}{ll} \textit{psoa} & \\ \text{SPKR} & \boxed{2} \\ \text{ADDR} & \boxed{3} \end{array}\right] \\
\text{BACKGROUND} & \left\{\left[\begin{array}{ll}
\textit{mutually-believe} & \\
\text{EXPERIENCER} & \boxed{2} \\
\text{STANDARD} & \boxed{3} \\
\text{SOA} & \left[\begin{array}{ll}
\textit{normally-believe} & \\
\text{EXPERIENCER} & \textit{English speakers} \\
\text{SOA} & \left[\begin{array}{ll} \textit{canis} & \\ \text{INST} & \boxed{1} \end{array}\right]
\end{array}\right]
\end{array}\right]\right\}
\end{array}\right]
\end{array}\right]$$

Adding beliefs to CONTEXT provides the representational means to integrate (at least some kinds of) presuppositions, illocutionary force and deferred reference (Nunberg 1978) into grammar. However, a fuller model of speech acts and meaning transfers is still needed (Kathol et al. 2011: 94).

Taking a closer look at the argument underlying adding mutual beliefs to CONTEXT, one notices a striking similarity of shared assumptions about standard uses with *community membership* as a source for common ground (but see Footnote 4 for a hint on a possible refinement). However, community membership is just one of three sources of information on which the common ground between two

foxes, coyotes and wolves, which are, outside of biological contexts, usually not described as being dogs. This indicates that the EXPERIENCER group should be further restricted and allowed to vary over different language communities and genres.

interlocutors (scaling up to multilogue is obvious) can be based, according to Clark & Marshall (1981) and Clark et al. (1983):

> The first is *perceptual evidence*, what the two have jointly experienced or are jointly experiencing at the moment. The second is *linguistic evidence*, what the two have jointly heard said or are now jointly hearing as participants in the same conversation. The third is *community membership*. They take as common ground everything they believe is universally, or almost universally, known, believed, or supposed in the many communities and subcommunities to which they mutually believe they both belong. (Clark et al. 1983: 247)

Reconsidering the "*dog*-used-to-refer-to-remote-control" example mentioned above: in order for this kind of reference to happen, one can imagine a preparatory sequence like the following:

(7) Can you please give me the … what's the name? … the … ah, let's call it "dog" … can you please give me the dog?

In this monologue, the speaker establishes a name for the remote control. After this name-giving, the situationally re-coined term can be used referentially (see Lücking et al. 2006 on situated conventions). Obviously, the felicity of reference is due to *linguistic evidence* provided and agreed upon in dialogical exchange. Dialogue contexts (Lee-Goldman 2011) and the dynamics of common ground is a dimension which is absent in the static CONTEXT representations surveyed above. This is where dynamic update semantics enters the stage.

2.4 Towards an update semantics for dialogue

Starting from Stalnakerian contexts (Stalnaker 1978; see also Lewis 1979), that is, contexts which consist of mutually known propositions (also corresponding roughly to the mutual belief structures employed by Green 1996, cf. Section 2.3), Ginzburg argues in a series of works that this context actually has a more elaborate structure (Ginzburg 1994; 1996; 1997). One motivation for this refinement is found in data like (8), an example given by Ginzburg (1994: 2) from the London-Lund corpus (Svartvik 1990).

(8)

1.	A:	I've been at university.
2.	B:	Which university?
3.	A:	Cambridge.
4.	B:	Cambridge, um.

5. what did you read?
6. A: History and English.
7. B: History and English.

There is nothing remarkable about this dialogical exchange; it is a mundane piece of natural language interaction. However, given standard semantic assumptions and a *given-new* information structuring as sketched in Section 2.2, (8) poses two problems. The first problem is that one and the same word, namely *Cambridge*, plays a different role in different contexts as exemplified by turns 2 to 3 on the one hand and turns 3 to 4 on the other hand. The reason is that the first case instantiates a question-answering pair, where *Cambridge* provides the requested referent. The second case is an instance of *accept*: speaker B not only signals that she heard what A said (what is called *acknowledge*), but also that she updates her information state with a new piece of information (namely that A studied in Cambridge).

The second problem is that neither of B's turns 4 and 7 is redundant, although neither of them contribute new information (or *foci*) in the information-structural sense of Section 2.2: the turns just consist of a replication of A's answer. The reason for non-redundancy obviously is that in both cases the repetition manifests an *accept* move in the sense just explained.

In order to make grammatical sense out of such dialogue data – eventually in terms of linguistic competence – contextual background rooted in language is insufficient, as discussed. The additional context structure required to differentiate the desired interpretation of (8) from redundant and co-text-insensitive ones is informally summarised by Ginzburg (1994: 4) in the following way:

- FACTS: a set of commonly agreed upon facts;
- QUD ("question under discussion"): a partially ordered set that specifies the currently discussable questions. If q is topmost in QUD, it is permissible to provide any information specific to q.
- LATEST-MOVE: the content of *latest move* made: it is permissible to make whatever moves are available as reactions to the latest move.

Intuitively, turn 2 from the question-answer pair in turns 2 and 3 from (8) directly introduces a *question under discussion* – a semi-formal analysis is postponed to Section 4, which introduces the required background notions of *dialogue gameboards* and *conversational rules* which regiment dialogue gameboard updating. Given that in this case the *latest move* is a question, turn 3 is interpreted as an answer relating to the most recent question under discussion. This answer, however, is not simply added to the dialogue partners' common knowledge, that is, the *facts*. Rather, the receiver of the answer first has to *accept* the response offered to him – this is the dialogue reading of "It takes two to make a truth". After acceptance, the answer can be *grounded* (see Clark 1996: Chapter 4 for a discussion of common ground), that is, *facts* is *updated* with the proposition bound up with the given answer, the resolved question under discussion is removed from the QUD list (*downdating*) – in a nutshell, this basic mechanism is also the motor of the dialogue progressing. This mechanism entails an additional qualification compared to a static mutual belief context: dialogue update does not abstract over the individual dialogue partners. A dialogue move does not present the same content to each of the dialogue partners, nor does the occurrence of a move lead automatically to an update of the common ground (or mutual beliefs). Dialogue semantics accounts for this fact by distinguishing *public* from *private* information. Public information consists of observable linguistic behaviour and its conventional interpretations, collected under the notion of *dialogue gameboard* (DGB). The DGB can be traced back to the *commitment-stores* of Hamblin (1970) that keep track of the commitments made at each turn by each speaker.

Private information is private since it corresponds to interlocutors' mental states (MS). The final ingredient is that the (fourfold) dynamics between the interlocutors' dialogue game boards and mental states unfolds in time, turn by turn. In sum, a minimal participant-sensitive model of dialogue contributions is a tuple of DGB and MS series of the form $\langle \text{DGB} \times \text{MS}\rangle^{+}$ for each dialogue agent. Here the tuple represents a temporarily ordered sequence of objects of a given type (i.e. DGB and MS in case of dialogue agents' information state models) which is witnessed by a *string* of respective events which at least of length 1, as required by the "Kleene +" (see Cooper & Ginzburg 2015: Section 2.7 on a type-theoretical variant of the string theory of events of Fernando 2011).

Guided by a few dialogue-specific semantic phenomena, we moved from various extensions to CONTEXT to minimal participant models and updating/downdating dynamics. In Sections 3 and 4, further progress which mainly consists of inverting the theory's strategic orientation is reviewed: instead of extending HPSG in order to cover pragmatics and dialogue semantics, it is argued that there are reasons to start with an interactive semantic framework and then embed an HPSG variant therein.

In order to move on, a remaining issue has to be resolved: what happens if an addressee for some reason refuses to accept a contribution of the previous speaker? In this case, the addressee (now taking the speaker role) poses a *clarifi-*

cation request. Clarification potential plays an important methodological role in the dialogue semantic business, as exemplified in Section 3.1 below.

3 Type-theoretical pragmatics and dialogue semantics

A minimal primer for the rich type theory TTR is given in Section 3.3. But why should (dialogue) semantics make use of a type theory at all? In what follows, two sources of motivation are presented, the one drawing on semantic data gained from the clarification potential of reprise fragments (Section 3.1), the other resulting from HPSG's struggle with connecting to semantic theories (Section 3.2).

3.1 Subsentential meanings: unification and constraint-satisfaction vs. reprise content

In (9), B poses a clarification request in terms of a reprise fragment concerning the verb used by A (Ginzburg 2012: 115):

(9)
1. A: Did Bo finagle a raise?
2. B: Finagle?

The reprise fragment has at least two interpretations: it can query the phonetic component of the verb ("did I hear correctly that you said 'finagle'?"), or it can query the meaning of the verb ("what does 'finagle' mean?"). Both queried aspects are available as part of the PHON-SYNSEM structure of signs, emphasizing the significance of HPSG's fractal design (cf. the remark on fractality in Section 2.2). However, when B uses the reprise fragment to clarify the content of the expression reprised, then B queries *only* the meaning of the reprised fragment (Purver & Ginzburg 2004; Ginzburg & Purver 2012) – in our example (9), this is *finagle*. This can be seen when answers are given that target the head verb or the verb phrase (head verb plus direct object argument *a raise*):

(10) Finagle?
  a. Yeah, like wangle.
  b. Yeah, he wangled a wage increase.

From the continuations in (10) only the first one provides an answer to B's clarification question in (9). The second continuation can also answer a clarification request, but this clarification request is *finagle a raise?* That is, "[a] nominal fragment reprise question queries exactly the standard semantic content of the fragment being reprised", which is the strong version of the *Reprise Content Hypothesis* put forth by Purver & Ginzburg (2004: 288).[5] In case of the example given in (9), the content of the head verb is queried, and not the meaning of the verb phrase (verb plus direct object) or the sentence (verb plus direct object and subject), since they correspond to constructions that are larger than the reprised fragment. In other words, a reprise fragment allows us to access the meaning of any expression regardless of its syntactic degree of embedding. However, this is not what follows from unification-based semantics. Due to structure sharing, certain slots of a head are *identified* with semantic contributions of modifier or argument constructions (see Wechsler, Koenig & Davis 2019, Chapter 9 of this volume). In the case of *finagle a raise*, this means that once the content of the VP is composed, the patient role (or whatever semantic composition means are employed – see Koenig & Richter 2019, Chapter 23 of this volume for an overview) of the verb *finagle* is instantiated by the semantic index contributed by *a raise*. At this stage one cannot recover the V content from the VP content – unification appears to be too strong a mechanism to provide contents at all levels as required by reprise fragments.

However, as Richter (2000: Chapter 2) argues, unification is only required in order to provide a formal foundation for the *language-as-partial-information* paradigm of Pollard & Sag (1987) and its spin-offs. The *language-as-collection-of-total-objects* paradigm underlying Pollard & Sag (1994) and its derivatives is not in need of employing unification. Rather, grammars following this paradigm are model-theoretic, constraint-based grammars, resting on *Relational Speciate Re-entrant Language* (RSRL) as formal foundation (Richter 2000 via precursors like Penn 1999). The formalism RSRL in its most recent implementation (Richter 2004) has the advantage that the models it describes can be interpreted in different ways.[6] On the one hand, it is compatible with the idea that grammars accumulate constraints that describe classes of (well-formed) linguistic objects, which in turn classify models of linguistic tokens (King 1999). On the other hand, it is compatible with the view that grammars describe linguistic types, where types are construed as equivalence classes of utterance tokens (Pollard 1999). On these accounts, a related argument applies nonetheless: once the constraints are accumulated that describe total objects with the PHON string *finagle a raise*, the superset of total objects corresponding to just *finagle* is not available any more. The implications of clarification data for any kind of grammar, in particular for

[5]The weak version (Purver & Ginzburg 2004: 287) only claims that a nominal fragment reprise question queries a part of the standard semantic content of the fragment being reprised.

[6]Richter (2019) *p.c.*; see also Richter (2019), Chapter 3 of this volume.

semantics, seem to be that some mechanism is needed that keeps track of the semantic contribution of each constituent of complex linguistic objects such as the verb *finagle* within the verb phrase *finagle a raise*. We do not know of any such attempts within constraint-based grammars and of the possible formal intricacies that may be involved, however. In the following, therefore, the HPSG_{TTR}/KoS framework that provides trackable constituents by means of labelled representations and a dialogue gameboard architecture is introduced. We should emphasize to the reader that at this point we leave the formal background of standard HPSG as documented in this book. We want to point this out since the subsequently-used representations look deceptively similar to attribute-value matrices (the risk of confusion is known from the essentially identical representations employed within unification- and constraint-based HPSG variants). We see this as a consequence of the dynamics of theories when their empirical domain is extended; at best, it adds to the formal and conceptual controversies and developments that take place in HPSG anyway, as briefly sketched in the beginning of this paragraph. However, HPSG_{TTR} aims at adopting most of HPSG's desirable features such as its fractal architecture, its sign-based set-up and its linking facility between different layers of grammatical description. To begin with, we want to further motivate the point of departure in terms of HPSG's semantic objects.

3.2 Semantic objects: data structures vs. types

Aiming at a declarative characterisation of natural languages, the model theoretic set-up of HPSG has to define models for its domain of linguistic objects (Levine & Meurers 2006: Section 3; see also Richter 2019, Chapter 3 of this volume). In particular with regard to the values of the CONTENT and CONTEXT attribute, the crucial question is "how types in the [feature] logic should correspond to the semantic types being represented" (Penn 2000: 70). In order to provide an answer to this crucial question, one has to clarify what a semantic type is. This question, however, is perhaps even more far-reaching and intricate than the initial one and following it further would lead us to undertake a considerable diversion and probably even turn away from the actual point of the initial question (but for a recent related discussion on the status of propositions see King et al. 2014). A pragmatic interpretation of the crucial question probably is this: how do the types in the feature logic correspond to the semantic types employed in semantic theories? There is a justification for this restatement from the actual semantic practice in HPSG (cf. Koenig & Richter 2019, Chapter 23 of this volume).

For the purpose of the present discussion, a semantic theory can be conceived as consisting of two components, *semantic representations* and an extensional *domain* or *universe* within which the semantic representations are interpreted (Zimmermann 2011; Kempson 2011). That is, another reformulation of the question is how the HPSG model theory is related to a semantic model theory. Further concreteness can be obtained by realising that both kinds of theories aim to talk about the same extensional domain. Given this, the question becomes: how do HPSG's semantic representations correspond to the semantic representation of the semantic theory of choice? A closely related point is made by Penn (2000: 63): "A model-theoretic denotation could be constructed so that nodes, for example, are interpreted in a very heterogeneous universe of entities in the world, functions on those entities, abstract properties that they may have such as number and gender and whatever else is necessary – the model theories that currently exist for typed feature structures permit that […]". Formulating things in this way has a further advantage: the question is independent from other and diverging basic model theoretic assumptions made in various versions of HPSG, namely whether the linguistic objects to model are types (Pollard & Sag 1994) or tokens (Pollard & Sag 1987) and whether they are total objects (Pollard & Sag 1994) or partial information (Carpenter 1992). However, such a semantic model-theoretic denotation of nodes is not available in many of the most influential versions of HPSG: the semantic structures of the HPSG version developed by Pollard & Sag (1994) rests on a situation-theoretic framework. However, the (parameterised) states of affairs used as semantic representations lack a direct model-theoretic interpretation; they have to be translated into situation-theoretic formulæ first (such a translation from typed feature structures to situation theory is developed by Ginzburg & Sag 2000). That is, the semantic structures do not encode semantic entities; rather they are data structures that represent descriptions which in turn correspond to semantic objects. This is also the conclusion drawn by Penn. The quotation given above continues: "[…] but at that point feature structures are not being used as a formal device to represent knowledge but as a formal device to represent data structures that encode formal devices to represent knowledge" (Penn 2000: 63; see also the discussion given by Ginzburg 2012: Section 5.2.2).

There are two options in order to unite typed feature structures and semantic representations. The first is to use logical forms instead of (P)SOAs and by this means connect directly to truth-conditional semantics. This option makes use of what Penn (see above) calls a *heterogeneous universe*, since syntactic attributes receive a different extensional interpretation than semantic attributes (now consisting of first or second order logic formulæ). The second option is to resort to a homogeneous universe and take PHON-SYNSEM structures as objects in the world, as is done in type-theoretical frameworks – signs nonetheless stand out from ordinary objects due to their CONT part, which makes them representational entities in the first place.

The first option, using logical forms instead of situation-semantic (P)SOAS, was initiated by Nerbonne (1992). The most fully worked out semantics for HPSG from this strand has been developed by Richter and Sailer, by providing a mechanism to use the higher-order Ty2 language for semantic descriptions (Richter & Sailer 1999). This approach has been worked out in terms of *Lexical Resource Semantics* (LRS) where logical forms are constructed in parallel with attribute-value matrices (Richter & Sailer 2004).

At this point we should insert a word on HPSG's most popular underspecification mechanism, namely *(Robust) Minimal Recursion Semantics* (Copestake, Flickinger, Pollard & Sag 2005; Copestake 2007). (R)MRS formulæ may have unfilled argument slots so that they can be assembled in various ways. However, resolving such underspecified representations is not part of the grammar formalism, so (R)MRS representations do not provide an autonomous semantic component for HPSG. Therefore, they do not address the representation problem under discussion as LRS does.

The second option, using the type-theoretical framework TTR, has been developed by Cooper (2008; 2014; 2019) and Ginzburg (2012). TTR, though looking similar to feature structures, directly provides semantic entities, namely types (Ginzburg 2012: Sec. 5.2.2). TTR also has a model-theoretic foundation (Cooper 2019), so it complies with the representation-domain format we drew upon above.

Turning back to the issue discussed in Section 3.1, there is a difference between the two semantic options. Relevant observations are reported by Purver & Ginzburg (2004) concerning the clarification potential of noun phrases. They discuss data like the following (bold face added):

(11) a. TERRY: Richard hit the ball on the car.
NICK: **What ball**? *[⇝ What ball do you mean by 'the ball'?]*
TERRY: James [last name]'s football.

(BNC file KR2, sentences 862, 865–866)

b. RICHARD: No I'll commute every day
ANON 6: **Every day?** *[⇝ Is it* ***every*** *day you'll commute?]*
[⇝ Is it every ***day*** *you'll commute?]*
[⇝ Which days do you mean by ***every day****?]*
RICHARD: as if, er Saturday and Sunday
ANON 6: And all holidays?
RICHARD: Yeah [pause]

As testified in (11), the accepted answers which are given to the clarification requests are in terms of an *individual* with regard to *the ball* (11a) and in terms of *sets* with regard to *every day* in (11b). The expressions put to a clarification request (*the ball* and *every day*, respectively) are analysed as *generalised quantifiers* in semantics (Montague 1974). A generalised quantifier, however, denotes a *set of sets*, which is at odds with its clarification potential in dialogue. Accordingly, in a series of works, a theory of quantified noun phrases (QNPs) has been developed that refrains from type raising and that analyses QNPs in terms of the intuitively expected and clarificationally required denotations of types *individual* and *sets of individuals*, respectively (Purver & Ginzburg 2004; Ginzburg & Purver 2012; Ginzburg 2012; Cooper 2013; Lücking & Ginzburg 2018; Cooper 2019). Since this dialogue-friendly improvement has been given in terms of the second, type-theoretical option and is lacking in the first, logical form-based option (which usually involves generalised quantifier analyses), there is an empirical advantage for the former over the latter, at least from a pragmatic, dialogue semantics viewpoint.

There are further distinguishing features, however. Types are intensional entities, so they directly provide belief objects, as touched upon in Section 2.3, which are needed for intensional readings as figuring in attitude reports such as in the assertion that *Flat Earthers believe that the earth is flat* (see also Cooper 2005a and Cooper 2019 on attitude reports in TTR).

Furthermore, TTR is not susceptible to the *slingshot argument* (Barwise & Perry 1983: 24–26): explicating propositional content on a Fregean account (Frege 1892) – that is, denoting the true or the false – in terms of sets of possible worlds is too coarse-grained, since two sentences which are both true (or false) but have nonetheless different meanings cannot be distinguished. In this regard, TTR provides a *structured theory of meaning*, where types are not traded for their extensions. Accordingly, a brief introduction to TTR is given in Section 3.3 and the architecture of the dialogue theory *KoS* incorporating a type-theoretic HPSG variant is sketched in Section 4.

3.3 A brief primer on TTR

TTR, which builds on ideas in the intuitionistic Type Theory of Martin-Löf (1984) and its application to natural language semantics (see Ranta 2015), provides semantic objects at both the token and the type level and structures to organise these objects, namely records and record types (see Cooper 2005b, Cooper 2005a, Cooper 2012, Cooper 2017, and Cooper & Ginzburg 2015 for expositions). Records consist of fields of pairs of labels and objects, and record types consist of fields of pairs of labels and types, which both can be nested (Cooper 2019). Take for instance the schematic record in (12):

(12) $$\begin{bmatrix} l_0 & = & \begin{bmatrix} l_1 & = & o_1 \\ l_2 & = & o_2 \end{bmatrix} \\ l_3 & = & o_3 \end{bmatrix}$$

Here, o_1, o_2 and o_3 are (real-world) objects, which are labelled by l_1, l_2 and l_3, respectively (o_1 and o_2 are additionally part of a sub-record labelled l_0). Records can be *witnesses* for record types. For instance, the record from (12) is a witness for the record type in (13) only in the case that the objects from the record are of the type required by the record type (i.e. $o_1 : T_1$, $o_2 : T_2$, $o_3 : T_3$), where objects and types are paired by same labelling.

(13) $$\begin{bmatrix} l_0 & : & \begin{bmatrix} l_1 & : & T_1 \\ l_2 & : & T_2 \end{bmatrix} \\ l_3 & : & T_3 \end{bmatrix}$$

The colon notation indicates a basic notion in TTR: a *judgement*. A judgement of the form $a : T$ means that object a is of type T, or, put differently, that a is a witness for T. Judgements are used to capture basic classifications like *Marc Chagall is an individual* (*mc* : *Ind*), as well as propositional descriptions of situations like *The cat is on the mat* for the situation depicted in Figure 1, where Fritz the cat sits on mat m33. The record type for the example sentence (ignoring the semantic contribution of the definite article for the sake of exposition[7]) will be (14):

(14) $$\begin{bmatrix} \text{x} & : & \mathit{Ind} \\ \text{c1} & : & \mathit{cat(x)} \\ \text{y} & : & \mathit{Ind} \\ \text{c2} & : & \mathit{mat(y)} \\ \text{c3} & : & \mathit{on(x,y)} \end{bmatrix}$$

Note that the types labelled "c1", "c2", and "c3" in (14) are *dependent types*, since the veridicality of judgements involving these types depends on the objects that are assigned to the basic types labelled "x" and "y". A *witness* for the record type in (14) will be a *record* that provides suitable objects for each field of the record type (and possibly more). Obviously, the situation depicted in Figure 1 (adapted from Lücking 2018: 270) is a witness for the type in (14). The participants of the depicted situation can be thought of as situations themselves which show Fritz to be a cat, m33 to be a mat and Fritz to be on m33. The scene in the figure then

[7] This record type corresponds to *a cat is on a mat.*

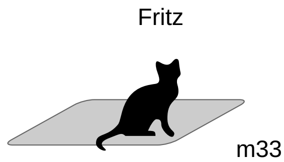

Figure 1: Fritz the cat sits on a mat.

corresponds to the following record, which is of the type expressed by the record type from (14):

(15) $\begin{bmatrix} \text{x} & = & \textit{Fritz} \\ \text{c1} & = & \textit{cat situation} \\ \text{y} & = & \textit{m33} \\ \text{c2} & = & \textit{mat situation} \\ \text{c3} & = & \textit{relation situation} \end{bmatrix}$

Using type constructors, various types can be build out of basic and complex (dependent) types, such as set types and list types. In order to provide two (slightly simplified) examples of type constructors that will be useful later on, we just mention *function types* and *singleton types* here.

(16) Function type

a. If T_1 and T_2 are types, then $(T_1 \rightarrow T_2)$ is a type, namely the type of functions that map T_1 to T_2.

b. If a function f is of type $(T_1 \rightarrow T_2)$ then f's domain is $\{a \mid a : T_1\}$ and its range is included in $\{a \mid a : T_2\}$.

The characterisation in (16) is that of a standard extensional notion of function. Given that TTR is an intensional semantic theory – that is, two types are different even if their extension is the same – other notions of function types could be developed.

(17) Singleton type

a. If T is a type and $a : T'$ (i.e. object a is of type T'), then T_a is a type.

b. $b : T_a$ (i.e. object b is of type T_a) iff $b : T$ and $b = a$.

That is, a singleton type is singleton since it is the type of specific object.

Since types are semantic objects in their own right (types are not defined by or reduced to their extensions), not only an object o of type T can be the value of a label, but also type T itself. One way of expressing this is in terms of *manifest* *fields*. A type-manifest field is notated in the following way: $l = T : T'$, specifying that l is the type T. Analogously, object-manifest fields can be expressed by restricting the value of a label to a certain object.

For more comprehensive and formal elaborations of TTR, see the references given at the beginning of this section, in particular Cooper (2019).

4 Putting things together: HPSG$_{\text{TTR}}$ and dialogue game boards

Signs as construed within HPSG can be reconstructed as record types of a specific kind (Cooper 2008). For instance, (18) shows the record type (the judgement colon indicates that we now talk about TTR objects) for a general sign according to Pollard & Sag (1994) (where *PhonType*, *CategoryType* and *SemType* denote obvious types – see the Appendix for a minimal HPSG fragment defined in terms of TTR).

(18) $$\begin{bmatrix} \text{PHON} & : & \textit{list(PhonType)} \\ \text{SYNSEM} & : & \begin{bmatrix} \text{LOCAL} & : & \begin{bmatrix} \text{CAT} & : & \textit{CategoryType} \\ \text{CONTENT} & : & \textit{SemType} \\ \text{CONTEXT} & : & \textit{SemType} \end{bmatrix} \end{bmatrix} \end{bmatrix}$$

Signs are extended by an interface to circumstantial features of the utterance situation in terms of the DGB-PARAMS attribute, which corresponds to the C-INDS from Section 2.1. The attribute's name abbreviates *dialogue gameboard parameters* , since its values have to be instantiated (that is, witnessed) in the process of grounding. Thus, if the content of an NP α is part of DGB-PARAMS, then α gets a referential interpretation. However, NPs need not be used referentially; there are what Donnellan (1966) calls *attributive uses* as in *The thief (whoever he is) stole my credit card*. To this end, there is a "coercion" operation from DGB-PARAMS to Q-PARAMS (*quantificational parameters*) involving an abstraction from individuals to α's descriptive condition (Purver & Ginzburg 2004; see the Appendix for the respective operation).

These HPSG$_{\text{TTR}}$ signs figure as constituents within an architecture known as *dialogue gameboard*, giving rise to a grammar-dialogue interface within the dialogue theory *KoS* (Ginzburg 1994; 1996; 2003; 2012). A Dialogue Game Board (DGB) is an information-state based sheet for describing communicative interactions. The DGB from KoS tracks the interlocutors (*spkr* and *addr* fields), a record of the dialog history (*Moves*), dialogue moves that are in the process of grounding (*Pending*), the question(s) currently under discussion (*QUD*), the assumptions shared among the interlocutors (*Facts*) and the dialogue participant's view of the visual situation and attended entities (*VisualSit*). The TTR representation of a DGB following Ginzburg (2012) is given in (19), where *LocProp* is the type of a *locutionary proposition* (see (21) below) and *poset* abbreviates "partially ordered set".

(19) $$\begin{bmatrix} \textsc{spkr} & : & \textit{Ind} \\ \textsc{addr} & : & \textit{Ind} \\ \textsc{utt-time} & : & \textit{Time} \\ \textsc{c-utt} & : & \textit{addressing(spkr, addr, utt-time)} \\ \textsc{facts} & : & \textit{set(Prop)} \\ \textsc{visualsit} & : & \textit{RecType} \\ \textsc{pending} & : & \textit{list(LocProp)} \\ \textsc{moves} & : & \textit{list(LocProp)} \\ \textsc{qud} & : & \textit{poset(Question)} \end{bmatrix}$$

TTR, like many HPSG variants (e.g. Pollard & Sag 1987 and Pollard & Sag 1994), employs a situation semantic domain (Cooper 2019). This involves propositions being modelled in terms of types of situations, not in terms of sets of possible worlds. Since TTR is a type theory, it offers at least two explications of proposition. On the one hand, propositions can be identified with types (Cooper 2005a). On the other hand, propositions can be developed in an explicit Austinian (Austin 1950) way, where a proposition is individuated in terms of a situation and situation type (Ginzburg 2011: 845) – this is the truth-making (and Austin's original) interpretation of "It takes two to make a truth", since on Austin's conception a situation type can only be truth-evaluated against the situation it is about. We follow the latter option here. The type of propositions and the relation to a situation semantics conception of "true" (Barwise & Perry 1983) is given in (20):

(20) a. $$\textit{Prop} =_{def} \begin{bmatrix} \textsc{sit} & : & \textit{Record} \\ \textsc{sit-type} & : & \textit{RecType} \end{bmatrix}$$

b. A proposition $p = \begin{bmatrix} \textsc{sit} & = & s \\ \textsc{sit-type} & = & T \end{bmatrix}$ is true iff $s : T$.

A special kind of proposition, namely *locutionary propositions* (*LocProp*) (Ginzburg 2012: 172), can be defined as follows:

(21) $$\textit{LocProp} =_{def} \begin{bmatrix} \textsc{sign} & : & \textit{Record} \\ \textsc{sign-type} & : & \textit{RecType} \end{bmatrix}$$

Locutionary propositions are sign objects utilized to explicate clarification potential (see Section 3.1) and grounding.

Given the dialogue-awareness of signs just sketched, a content for interjections such as "EHHH HEHH" which constitutes turn 3 from the exchange between Ann and Ray in (1) at the beginning of this chapter can be given. Intuitively, Ann signals with these sounds that she heard Ray's question, which in turn is neither grounded nor clarified at this point of dialogue but is waiting for a response, what is called *pending*. This intuition can be made precise by means of the following lexical entry (which is closely related to the meaning of *mmh* given by Ginzburg 2012: 163):

(22)
$$\begin{bmatrix} \textsc{phon} : \langle \text{ EHH HEHH } \rangle \\ \textsc{cat} : \begin{bmatrix} \textsc{head}{=}\textit{interjection} : \textit{syncat} \end{bmatrix} \\ \textsc{dgb-params} : \begin{bmatrix} \textsc{spkr} & : \textit{Ind} \\ \textsc{addr} & : \textit{Ind} \\ \textsc{pending} & : \textit{LocProp} \\ \textsc{c2} & : \textit{address(spkr,addr,pending)} \end{bmatrix} \\ \textsc{cont}{=}\textit{Understand}(\textsc{spkr,addr,dgb-params.pending}) : \textit{IllocProp} \end{bmatrix}$$

Knowing how to use feedback signals such as the one in (22) can be claimed to be part of linguistic competence. It is difficult to imagine how to model this aspects of linguistic knowledge if not by means of *grammar in dialogue*.

Dialogue gameboard structures as defined in (19) as well as lexical entries for interjections such as (22) are still *static*. The mechanism that is responsible for the dynamics of dialogue and regiments the interactive evolution of DGBs is *conversational rules*. A conversational rule is a mapping between an input and an output information state, where the input DGB is constrained by a type labelled *preconditions* (PRE) and the output DGB is subject to EFFECTS. That is, a conversational rule can be notated in the following form, where *DGBType* is the type of dialogue gameboards defined in (19).

(23)
$$\begin{bmatrix} \textsc{pre} & : \textit{DGBType} \\ \textsc{effects} & : \textit{DGBType} \end{bmatrix}$$

Several basic conversational rules are defined in Ginzburg (2012: Chapter 4) and some of them, namely those needed to analyse example (8) discussed above, are re-given below (with "Fact update/QUD-downdate" being simplified, however). *IllocProp* abbreviates "Illocutionary Proposition", *IllocRel* "Illocutionary Relation", *poset* "Partially Ordered Set", *AbSemObj* "Abstract Semantic Object" and *QSPEC* "Question-under-Discussion-Specific". With regard to the partially ordered QUD set, we use "$\langle u, X\rangle$" to denote the upper bound u for subset X. For details, we have to refer the reader to Ginzburg (2012); we believe the following list to convey at least a solid impression of how dialogue dynamics works in KoS, however.

- Free Speech:

$$\begin{bmatrix} \text{PRE} & : & \begin{bmatrix} \text{QUD}=\langle\rangle & : & \textit{poset(Question)} \end{bmatrix} \\ \text{EFFECTS} & : & \textit{TurnUnderspec} \wedge_{merge} \begin{bmatrix} \text{r} : \text{AbSemObj} \\ \text{R} : \text{IllocRel} \\ \text{LatestMove}=\text{R(spkr,addr,r)} : \text{IllocProp} \end{bmatrix} \end{bmatrix}$$

- QSPEC:

$$\begin{bmatrix} \text{PRE} & : & \begin{bmatrix} \text{QUD}=\langle \text{q,Q} \rangle & : & \textit{poset(Question)} \end{bmatrix} \\ \text{EFFECTS} & : & \textit{TurnUnderspec} \wedge_{merge} \begin{bmatrix} \text{r} : \text{AbSemObj} \\ \text{R} : \text{IllocRel} \\ \text{LatestMove}=\text{R(spkr,addr,r)} : \text{IllocProp} \\ \text{c1} : \text{Qspecific(r,q)} \end{bmatrix} \end{bmatrix}$$

- Ask QUD-incrementation:

$$\begin{bmatrix} \text{PRE} & : & \begin{bmatrix} \text{q} & : & \textit{Question} \\ \text{LatestMove}=\text{Ask(spkr,addr,q)} & : & \textit{IllocProp} \end{bmatrix} \\ \text{EFFECTS} & : & \begin{bmatrix} \text{QUD}=\langle \text{q,pre.qud} \rangle & : & \textit{poset(Question)} \end{bmatrix} \end{bmatrix}$$

- Assert QUD-incrementation:

$$\begin{bmatrix} \text{PRE} & : & \begin{bmatrix} \text{p} & : & \textit{Proposition} \\ \text{LatestMove}=\text{Assert(spkr,addr,p)} & : & \textit{IllocProp} \end{bmatrix} \\ \text{EFFECTS} & : & \begin{bmatrix} \text{QUD}=\langle \text{p?,pre.qud} \rangle & : & \textit{poset(Question)} \end{bmatrix} \end{bmatrix}$$

- Accept:

$$\begin{bmatrix} \text{PRE} & : & \begin{bmatrix} \text{spkr} & : & \textit{Ind} \\ \text{addr} & : & \textit{Ind} \\ \text{p} & : & \textit{Prop} \\ \text{LatestMove}=\text{Assert(spkr,addr,p)} & : & \textit{IllocProp} \\ \text{QUD}=\langle \text{p?,subqud} \rangle & : & \textit{poset(Question)} \end{bmatrix} \\ \text{EFFECTS} & : & \begin{bmatrix} \text{spkr=pre.addr} & : & \textit{Ind} \\ \text{addr=pre.sprk} & : & \textit{Ind} \\ \text{LatestMove}=\text{Accept(spkr,addr,p)} & : & \textit{IllocProp} \end{bmatrix} \end{bmatrix}$$

- Fact update/QUD-downdate (simplified):

$$- \left[\begin{array}{ll} \textsc{pre} & : \left[\begin{array}{ll} \textsc{q} & : \textit{Question} \\ \textsc{p} & : \textit{Prop} \\ \textsc{LatestMove}=\textsc{Accept}(\textsc{spkr},\textsc{addr},\textsc{p}) & : \textit{IllocProp} \\ \textsc{qud}=\left\langle \textsc{q},\textsc{subqud} \right\rangle & : \textit{poset(Question)} \\ \textsc{qbg} & : \textit{Qspecific(p,q)} \end{array}\right] \\ \textsc{effects} & : \left[\begin{array}{l} \textsc{facts}=\textsc{pre.facts} \cup \left\{\textsc{p}\right\} \ : \ \textit{Set(Prop)} \\ \textsc{qud}=\textsc{pre.qud} \setminus \left\{\textsc{q}\right\} \end{array}\right] \end{array}\right]$$

$$- \left[\begin{array}{ll} \textsc{pre} & : \left[\begin{array}{ll} \textsc{p} & : \textit{Prop} \\ \textsc{LatestMove}=\textsc{Accept}(\textsc{spkr},\textsc{addr},\textsc{p}) & : \textit{IllocProp} \\ \textsc{qud}=\left\langle \textsc{p}?,\textsc{subqud} \right\rangle & : \textit{poset(Question)} \end{array}\right] \\ \textsc{effects} & : \left[\begin{array}{l} \textsc{facts}=\textsc{pre.facts} \cup \left\{\textsc{p}\right\} \ : \ \textit{Set(Prop)} \\ \textsc{qud}=\textsc{pre.qud} \setminus \left\{\textsc{p}?\right\} \end{array}\right] \end{array}\right]$$

Having dialogue game boards and conversational rules at one's disposal, we can apply KoS' analytical tools to the dialogue example from (8) above. We make the following simplifying assumptions: if the nth move is an assertion, we refer to the asserted proposition in terms of "p(n)". The corresponding question *whether p(n)* is notated "p?(n)". If the nth move is a question, we refer to the question in terms of "q(n)". Additionally, we assume that subsentential utterances project to Austinian propositions by resolving elliptical expressions in context in terms of their missing semantic constituents which are available as the contents of the maximal elements in QUD (that is, they are addressable via the path QUD.FIRST.CONT; cf. Ginzburg 2012).

Turn	DGB dynamics	Utterance / Conversational rule(s)
init.	$\left[\begin{array}{ll} \textsc{participants} & = \left\{\text{A,B}\right\} \\ \textsc{Moves} & = \left\langle \ \right\rangle \\ \textsc{qud} & = \left\langle \ \right\rangle \\ \textsc{facts} & = \textit{cg0} \end{array}\right]$	—
1.	$\left[\begin{array}{ll} \textsc{spkr} & = \textit{A} \\ \textsc{addr} & = \textit{B} \\ \textsc{Moves} & = \left\langle \textsc{Assert}(\text{A,B},\textsc{p}(1)) \right\rangle \\ \textsc{qud} & = \left\langle \textsc{p}?(1) \right\rangle \\ \textsc{facts} & = \textit{cg0} \end{array}\right]$	"I've been at university." Free Speech + Assert QUD-incrementation

2.	$\begin{bmatrix} \textsc{spkr} & = & B \\ \textsc{addr} & = & A \\ \textsc{Moves} & = & \left\langle \textsc{Ask}(\text{B,A,}\textsc{q}(2)),\ \textsc{Assert}(\text{A,B,}\textsc{p}(1)) \right\rangle \\ \textsc{qud} & = & \left\langle \textsc{q}(2) \right\rangle \\ \textsc{facts} & = & cg0 \cup \left\{ \textsc{p}(1) \right\} \end{bmatrix}$	“Which university?” Accept + Ask QUD-incrementation
3.	$\begin{bmatrix} \textsc{spkr} & = & A \\ \textsc{addr} & = & B \\ \textsc{Moves} & = & \left\langle \begin{matrix} \textsc{Assert}(\text{A,B,}\textsc{p}(3)), \\ \textsc{Ask}(\text{B,A,}\textsc{q}(2)),\ \textsc{Assert}(\text{A,B,}\textsc{p}(1)) \end{matrix} \right\rangle \\ \textsc{qbg} & = & \mathit{About(p(3),q(2))} \\ \textsc{qud} & = & \left\langle \textsc{p}?(3),\ \textsc{q}(2) \right\rangle \\ \textsc{facts} & = & cg0 \cup \left\{ \textsc{p}(1) \right\} \end{bmatrix}$	“Cambridge.” QSPEC (via *About* relation) + Assert QUD-incrementation
4.	$\begin{bmatrix} \textsc{spkr} & = & B \\ \textsc{addr} & = & A \\ \textsc{Moves} & = & \left\langle \begin{matrix} \textsc{Accept}(\text{B,A,}\textsc{p}(3)),\ \textsc{Assert}(\text{A,B,}\textsc{p}(3)), \\ \textsc{Ask}(\text{B,A,}\textsc{q}(2)),\ \textsc{Assert}(\text{A,B,}\textsc{p}(1)) \end{matrix} \right\rangle \\ \textsc{qud} & = & \langle \quad \rangle \\ \textsc{facts} & = & cg0 \cup \left\{ \textsc{p}(3),\ \textsc{p}(1) \right\} \end{bmatrix}$	“Cambridge, um.” Accept + Fact update/QUD-downdate
5.	$\begin{bmatrix} \textsc{spkr} & = & B \\ \textsc{addr} & = & A \\ \textsc{Moves} & = & \left\langle \begin{matrix} \textsc{Ask}(\text{B,A,}\textsc{q}(5)), \\ \textsc{Accept}(\text{B,A,}\textsc{p}(3)),\ \textsc{Assert}(\text{A,B,}\textsc{p}(3)), \\ \textsc{Ask}(\text{B,A,}\textsc{q}(2)),\ \textsc{Assert}(\text{A,B,}\textsc{p}(1)) \end{matrix} \right\rangle \\ \textsc{qud} & = & \left\langle \textsc{q}(5) \right\rangle \\ \textsc{facts} & = & cg0 \cup \left\{ \textsc{p}(3),\ \textsc{p}(1) \right\} \end{bmatrix}$	“what did you read?” Free Speech + Ask QUD-incrementation
6.	$\begin{bmatrix} \textsc{spkr} & = & A \\ \textsc{addr} & = & B \\ \textsc{Moves} & = & \left\langle \begin{matrix} \textsc{Assert}(\text{A,B,}\textsc{p}(6)),\ \textsc{Ask}(\text{B,A,}\textsc{q}(5)), \\ \textsc{Accept}(\text{B,A,}\textsc{p}(3)),\ \textsc{Assert}(\text{A,B,}\textsc{p}(3)), \\ \textsc{Ask}(\text{B,A,}\textsc{q}(2)),\ \textsc{Assert}(\text{A,B,}\textsc{p}(1)) \end{matrix} \right\rangle \\ \textsc{qbg} & = & \mathit{About(p(6),q(5))} \\ \textsc{qud} & = & \left\langle \textsc{p}?(6),\ \textsc{q}(5) \right\rangle \\ \textsc{facts} & = & cg0 \cup \left\{ \textsc{p}(3),\ \textsc{p}(1) \right\} \end{bmatrix}$	“History and English.” QSPEC (via *About* relation) + Assert QUD-incrementation

7.	$\begin{bmatrix} \text{SPKR} & = B \\ \text{ADDR} & = A \\ \text{MOVES} & = \left\langle \begin{array}{l} \text{ACCEPT(B,A,P(6))}, \\ \text{ASSERT(A,B,P(6))}, \text{ASK(B,A,Q(5))}, \\ \text{ACCEPT(B,A,P(3))}, \text{ASSERT(A,B,P(3))}, \\ \text{ASK(B,A,Q(2))}, \text{ASSERT(A,B,P(1))} \end{array} \right\rangle \\ \text{QUD} & = \langle\ \rangle \\ \text{FACTS} & = cg0 \cup \{\text{P(6)}, \text{P(3)}, \text{P(1)}\} \end{bmatrix}$	"History and English." Accept + Fact update/QUD-downdate

Note that the dialogical exchange leads to an increase of the common ground of the interlocutors A and B: after chatting, the common ground contains the propositions *that A has been at university* (p(1)), *that A has been at Cambridge University* (p(3)) and *that A read History and English* (p(6)).

On these grounds, a lexical entry for "hello" can be spelled out. "Hello" realises a greeting move (which is its content) and must be used discourse-initially (the MOVES list and the QUD set have to be empty):

(24)
$$\begin{bmatrix} \text{PHON} : \langle \text{ HELLO } \rangle \\ \text{CAT} : \left[\text{HEAD}{=}\textit{INTERJECTION} : \textit{syncat}\right] \\ \text{DGB-PARAMS} : \begin{bmatrix} \text{SPKR} & : \textit{Ind} \\ \text{ADDR} & : \textit{Ind} \\ \text{MOVES}{=}\langle\ \rangle & : \textit{list(IllocProp)} \\ \text{QUD}{=}\{\} & : \textit{poset(Question)} \end{bmatrix} \\ \text{CONT}{=}\text{GREET(SPKR,ADDR)}: \textit{IllocProp} \end{bmatrix}$$

Discourse-dynamically, "hello" puts a greeting move onto the MOVES list of the dialogue gameboard, thereby initiates an interaction and invites for a countergreeting (the requirement for countergreeting is exactly that a greeting move is the element of the otherwise empty list of dialogue moves) – giving rise to an *adjacency pair* as part of the local management system for dialogues investigated in conversational analysis (Schegloff & Sacks 1973).

The discourse particle "yes" can be used to answer a polar yes/no question. In this use, "yes" has a propositional content p that asserts the propositional content of the polar question p?, which has to be the maximal element in QUD (Ginzburg 2012: Chapter 2, 231 *et seq.*). That is, "yes" affirmatively resolves a given polar question. Polar questions, in turn, are 0-ary propositional abstracts (Ginzburg 2012: 231), that is, the polar question p? corresponding to a proposition p is a function mapping an empty record to p: $\lambda r : [].p$. Thus, applying p? to an empty record [] returns p, which is exactly what "yes" does. The affirmative particle (used to answer a yes/no question) is a propositional lexeme which applies a polar question which is maximal in QUD to an empty record (cf. Ginzburg 2012: 232):

(25)
$$\begin{bmatrix} \text{PHON} : \langle \text{ YES } \rangle \\ \text{CAT} : \begin{bmatrix} \text{HEAD}=\textit{PARTCL} : \textit{syncat} \end{bmatrix} \\ \text{DGB-PARAMS} : \begin{bmatrix} \text{QUD}=\begin{bmatrix} \text{MAX} : \textit{PolQuestion} \\ \text{REST} : \textit{set(Question)} \end{bmatrix} : \textit{poset(Question)} \end{bmatrix} \\ \text{CONT}=\text{DGB-PARAMS.QUD.MAX}(\ [\ ]\ ) : \textit{Prop} \end{bmatrix}$$

Due to its involvedness in DGB-PARAMS.QUD, "yes" directly interacts with accept and downdating, as described above. For more on this, see Ginzburg (2012).

5 Outlook

Given a basic framework for formulating and analysing content in dialogue context, there are various directions to explore, including the following ones.

- One of the main challenges of dialogue semantics is the integration of *non-verbal communication* means, like gaze, gestures, body posture, timing and non-language vocal sounds (e.g. laughter; Ginzburg et al. 2015; Tian et al. 2016). Since non-verbal communication means are informative, not only does a (dialogue) semantic representation have to be developed, but also the rules of their interaction with speech have to be formulated.

- Strictly speaking, dialogue is the interaction between *two* interlocutors. How can one scale up to *multilogue*, where the number of participants is at least three (Ginzburg & Fernández 2005)? Given the increased number of participants, problems that emerge include *grounding by proxy*, where a representative represents the dialogue gameboard of a group (Eshghi & Healey 2016) and of course *turn taking*.

- People do not process natural language input sentence-wise. Rather, processing begins with the initial sound and proceeds word for word or even on smaller units like affixes and phonemes – that is, processing is incremental (e.g. Sedivy et al. 1999; see also Wasow 2019, Chapter 27 of this volume). This is a key ingredient in the efficient (relatively gap-free and interruption-less) managing of turn taking. One direction of dialogue theories therefore is to bring psycholinguistics and formal semantics closer together by devising incremental grammar and dialogue gameboard models (Hough et al. 2015; Demberg et al. 2013; Poesio & Rieser 2011).

Finally, we want to mention two other dialogue-theoretic frameworks that have been worked out to a substantial degree, namely PTT (Traum 1994; Poesio 1995; Poesio & Traum 1997; Poesio & Rieser 2010), and *Segmented Discourse Representation Theory* (SDRT) (Asher 1993; Asher & Lascarides 2003; 2013; Hunter & Asher 2015). The phenomena and outlook directions discussed in this chapter apply to all theories of dialogue semantics, of course.

Appendix: An HPSG$_{\text{TTR}}$ fragment

The appendix provides a fragment of HPSG$_{\text{TTR}}$. The grammar framework used is oriented at a *Head-driven Phrase Structure Grammar* variant (Sag et al. 2003), namely its TTR implementation (Cooper 2008). We use HPSG because its architecture satisfies the property of *incremental correspondence* (Johnson & Lappin 1999) – utterance representations encode phonological, syntactic, semantic and contextual information *fractally*. This is crucial *inter alia* for any treatment of clarification interaction (cf. Section 3.1). We use HPSG$_{\text{TTR}}$ because the type-theoretical version allows us to directly incorporate semantic objects (cf. Section 3.2).

TTR has a counterpart to unification, namely the *merge* construction.

(26) a. If R_1 and R_2 are record types, then $R_1 \wedge_{merge} R_2$ is a record type and is called the *merge* of R_1 and R_2.

b. Since merge types are complicated to define (but see Cooper 2012), we follow the strategy of Cooper (2017) and illustrate the working of merges by means of some examples:

(i) $\begin{bmatrix} \text{A} & : & T \\ \text{B} & : & R \end{bmatrix} \wedge_{\textit{MERGE}} \begin{bmatrix} \text{C} & : & S \end{bmatrix} = \begin{bmatrix} \text{A} & : & T \\ \text{B} & : & R \\ \text{C} & : & S \end{bmatrix}$

(ii) $\begin{bmatrix} \text{A} & : & T \end{bmatrix} \wedge_{\textit{MERGE}} \begin{bmatrix} \text{A} & : & R \end{bmatrix} = \begin{bmatrix} \text{A} & : & T \wedge_{merge} R \end{bmatrix}$

Structure sharing is indicated by a “tag type” notation. Tag types are defined in terms of manifest fields.[8] The notational convention is exemplified in (27) by means of head-specifier agreement, where the tag type from (27a) abbreviates the structure in (27b):

[8] *NB:* technically, tag types apply singleton types to record types, instead of to objects, thereby making use of a revision of the notion of singleton types introduced by Cooper (2013: 4, footnote 3).

(27) a. $\left[\text{CAT} : \begin{bmatrix} \text{HEAD} & : & \left[\text{AGR}_{\boxed{1}} : \textit{Agr}\right] \\ \text{SPR} & : & \left\langle \left[\text{CAT} : \left[\text{HEAD} : \left[\text{AGR}{=}\boxed{1} : \textit{Agr}\right]\right]\right] \right\rangle \end{bmatrix}\right]$

b. $\left[\text{CAT} : \begin{bmatrix} \text{HEAD} & : & \left[\text{AGR} : \textit{Agr}\right] \\ \text{SPR} & : & \left\langle \left[\text{CAT} : \left[\text{HEAD} : \left[\text{AGR}{=}/\text{CAT.HEAD.AGR} : \textit{Agr}\right]\right]\right] \right\rangle \end{bmatrix}\right]$

The tag type notation alludes to the box notation common in HPSG work.

Agr is defined as usual:

(28) $\textit{Agr} \coloneqq \begin{bmatrix} \text{NUM} & : & \textit{Num} \\ \text{PERS} & : & \textit{Per} \\ \text{GEN} & : & \textit{Gen} \end{bmatrix}$

A basic *sign* is a pairing of phonetic, syntactic and semantic information and follows the geometry in (29):

(29) $\textit{sign} \coloneqq \begin{bmatrix} \text{PHON} & : & \textit{Phoneme} \\ \text{CAT} & : & \textit{SynCat} \\ \text{DGB-PARAMS} & : & \textit{RecType} \\ \text{CONT} & : & \textit{SemObj} \end{bmatrix}$

Signs employ DGB-PARAMS, which host referential meanings that are witnessed among interlocutors. Quantificational abstraction is achieved by coercing parts of DGB-PARAMS to Q-PARAMS:

(30) If DGB-PARAMS : R_2 and for two record types R_0 and R_1 lacking any mutual dependencies[9] $R_2 = R_0 \wedge_{merge} R_1$, then R_0 can be moved to Q-PARAMS, resulting in the following structure:

$\begin{bmatrix} \text{DGB-PARAMS} & : & R_1 \\ \text{CONT} & = & \left[\text{Q-PARAMS} : R_0\right] \end{bmatrix}$

A word is a sign with constituent type (CXTYPE) *word*. Using the merge operation, the word extension on signs can represented compactly as in (31a), which expands to the structure given in (31b):

(31) a. $\textit{word} \coloneqq \textit{sign} \wedge_{merge} \left[\text{CXTYPE} : \textit{word}\right] : \textit{RecType}$

b. $\begin{bmatrix} \text{CXTYPE} & : & \textit{word} \\ \text{PHON} & : & \textit{Phoneme} \\ \text{CAT} & : & \textit{SynCat} \\ \text{DGB-PARAMS} & : & \textit{RecType} \\ \text{CONT} & : & \textit{SemObj} \end{bmatrix}$

[9]None of the labels occurring in R_0 occur in R_1 and vice versa.

Words – that is, cxtype *word* – are usually the result of lexical rules, whose input are lexemes. Lexemes differ from words in their constituent type:

(32) $lexeme \coloneqq sign \wedge_{merge} \begin{bmatrix} \textsc{cxtype} : lexeme \end{bmatrix} : RecType$

A phrasal sign can be seen as a word with daughters:

(33) a. $$phrase \coloneqq sign \wedge_{merge} \begin{bmatrix} \textsc{cxtype} & : & phrase \\ \textsc{dtrs} & : & \begin{bmatrix} \textsc{nhd-dtrs} : List(Sign) \end{bmatrix} \end{bmatrix} : RecType$$

b. $$\begin{bmatrix} \textsc{cxtype} & : & phrase \\ \textsc{phon} & : & List(Phoneme) \\ \textsc{cat} & : & SynCat \\ \textsc{dgb-params} & : & RecType \\ \textsc{cont} & : & SemObj \\ \textsc{dtrs} & : & \begin{bmatrix} \textsc{nhd-dtrs} : List(Sign) \end{bmatrix} \end{bmatrix}$$

A headed phrase is a phrase with a prominent daughter, i.e. the head daughter:

(34) a. $$hd\text{-}phrase \coloneqq phrase \wedge_{merge} \begin{bmatrix} \textsc{dtrs} : \begin{bmatrix} \textsc{hd-dtr} : Sign \end{bmatrix} \end{bmatrix} : RecType$$

b. $$\begin{bmatrix} \textsc{cxtype} & : & phrase \\ \textsc{phon} & : & List(Phoneme) \\ \textsc{cat} & : & SynCat \\ \textsc{dgb-params} & : & RecType \\ \textsc{cont} & : & SemObj \\ \textsc{dtrs} & : & \begin{bmatrix} \textsc{hd-dtr} & : & Sign \\ \textsc{nhd-dtrs} & : & List(Sign) \end{bmatrix} \end{bmatrix}$$

The head daughter is special since it (as a default, at least) determines the syntactic properties of the mother construction. This aspect of headedness is captured in terms of the *head-feature principle* (HFP), which can be implemented by means of tag types as follows:

(35) $$\text{HFP} \coloneqq \begin{bmatrix} \textsc{cxtype} & : & phrase \\ \textsc{cat} & : & \begin{bmatrix} \textsc{head}_{\boxed{2}} : PoS \end{bmatrix} \\ \textsc{dtrs} & : & \begin{bmatrix} \textsc{hd-dtr} : \begin{bmatrix} \textsc{cat} : \begin{bmatrix} \textsc{head}{=}\boxed{2} : PoS \end{bmatrix} \end{bmatrix} \end{bmatrix} \end{bmatrix}$$

The fact that the daughters' locutions combine to the mother's utterance is captured in terms of a "phon principle" (we use a slash notation in order to indicate paths starting at the outermost level of a feature structure):

(36) $$\text{PHON} \coloneqq \begin{bmatrix} \textsc{cxtype} & : & phrase \\ \textsc{phon} & : & List(/dtrs.hd.dtr/phon, /dtrs.nhd.dtrs/pos1.phon, \\ & & \ldots, /dtrs.nhd.dtrs/posn.phon) \end{bmatrix}$$

Since semantic composition rests on predication rather than unification, there is no analog to the semantic compositionality principle of Sag et al. (2003) in our account. There is, however, something akin to semantic inheritance: we need to keep track of the contextual and quantificational paramaters contributed by the daughters of a phrase. This is achieved in terms of a *dgb-params principle* (*DGBPP*) in (37) which unifies the daughters' DGB-PARAMS into the mother's DGB-PARAMS (see Ginzburg 2012: 126 *et seq.* for a similar principle):

(37) DGBPP :=

$$\begin{bmatrix} \text{CXTYPE} & : & \textit{phrase} \\ \text{DGB-PARAMS} & : & \begin{bmatrix} /\text{DTRS.HD-DTR.DGB-PARAMS} \wedge_{MERGE} /\text{DTRS.NHD-DTRS.POS1.DGB-PARAMS} \wedge_{MERGE} \\ \ldots \wedge_{MERGE} /\text{DTRS.NHD-DTRS.POS}n\text{.DGB-PARAMS} \end{bmatrix} \\ \text{DTRS} & : & \begin{bmatrix} \text{HD-DTR} & : & \begin{bmatrix}\text{Q-PARAMS} : \textit{RecType}\end{bmatrix} \\ \text{NHD-DTRS} & : & \left\langle \text{POS1} : \begin{bmatrix}\text{Q-PARAMS} : \textit{RecType}\end{bmatrix}, \ldots, \textit{posn} : \begin{bmatrix}\text{Q-PARAMS} : \textit{RecType}\end{bmatrix} \right\rangle \end{bmatrix} \end{bmatrix}$$

A headed phrase is well-formed when it is a headed phrase and it obeys the head feature principle, the phon principle and the dgb-params principle, which is expressed by extending *hd-phrase* by the following constraint:

(38) $\textit{hd-phrase} := \textit{hd-phrase} \wedge_{merge} \text{HFP} \wedge_{merge} \text{PHON} \wedge_{merge} \text{DGBPP}$

Using this set-up, lexical entries, lexical rules and syntactic constructions can be formulated straightforwardly.

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