Chapter 30

Grammar in dialogue

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"It takes two to make a truth."
Austin (1950: 124, fn. 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 unification-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* is sketched that emerged in this way from work in HPSG.

1 Introduction

The archaeologists Ann Wesley and Ray Jones are working in an excavation hole, Ray Jones is looking at the excavation map. Suddenly, Ray discovered 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 huh huh
8. RAY: Uh::m,
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 is 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 (2018), Chapter 32 of this volume for a brief overview of non-verbal communication means), disfluencies (Ginzburg et al. 2014; turn 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), indirect reference (turn 10, where Ray points to an item on the map but refers to an archaeological artefact in the excavation hole). Such instances of deferred reference (Nunberg 1993) in situated communication actually differ from bridging anaphora (Clark 1975) in written texts (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 1982). 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). This position is strengthened by the primacy of spoken language in both ontogenetic and lan-

guage acquisition areas (on acquisition see Ginzburg (2018), Chapter 27 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 (Section 3.1 below). In light of this, the relevant arguments are briefly reviewed below. Subsequently, TTR (a Type Theory with Records) is briefly 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.

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). It 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 value provides pointers to cir-

cumstantial features of the utterance situation such as speaker, addressee, 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):

(2)
$$\left[\begin{array}{ll} \textit{word} & \\ \textsc{phon} & \textit{/she/} \\ \textsc{synsem} & \left[\begin{array}{ll} \textit{synsem} & \\ \textsc{local} & \left[\begin{array}{ll} \textit{local} & \\ \textsc{category} & \left[\begin{array}{ll} \textit{cat} & \\ \textsc{head} & \textit{noun}[\textsc{case}\ \textit{nom}] \\ \textsc{subcat} & \langle\ \rangle \end{array}\right] \\ \textsc{content} & \left[\begin{array}{ll} \textit{ppro} & \\ \textsc{index} & \boxed{1}\left[\begin{array}{ll} \textit{ref} & \\ \textsc{per} & \textit{3rd} \\ \textsc{num} & \textit{sing} \\ \textsc{gen} & \textit{fem} \end{array}\right] \\ \textsc{restr} & \{\} \end{array}\right] \\ \textsc{context} & \left[\begin{array}{ll} \textit{context} & \\ \textsc{background} & \left\{\left(\left[\begin{array}{ll} \textit{psoa} & \\ \textsc{reln} & \textit{female} \\ \textsc{inst} & \boxed{1} \end{array}\right]\right)\right\} \end{array}\right] \end{array}\right] \end{array}\right] \end{array}\right]$$

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 (2018), Chapter **??** of this volume; see also Wechsler (2018), 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 provides 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" (for a collection of indirect uses of *I*, or rather its German cognate *Ich*, where identification with the circumstantial speaker role would lead to wrong results, see Kratzer (1978)). This use of CONTEXT

is illustrated in (3), which is part of the lexical entry of *I* (see the Davis & Koenig (2018), Chapter 4 of this volume on the lexicalist orientation of HPSG).

(3)
$$\left[\begin{array}{ll} \textit{word} & \\ \textsc{phon} & \textit{/i/} \\ \textsc{synsem} & \left[\begin{array}{ll} \textit{synsem} & \\ \textsc{local} & \left[\begin{array}{ll} \textit{local} & \\ \textsc{content} & \left[\begin{array}{ll} \textit{ppro} & \\ \textsc{index} & \boxed{1}\left[\begin{array}{ll} \textit{ref} & \\ \textsc{ref} & \textit{1st} \\ \textsc{num} & \textit{sing} \end{array}\right] \\ \textsc{restr} & \{\} \end{array}\right] \\ \textsc{context} & \left[\begin{array}{ll} \textit{context} & \\ \textsc{c-inds} & \left[\begin{array}{ll} \textit{psoa} & \\ \textsc{spkr} & \boxed{1} \\ \textsc{addr} & \boxed{2} \\ \textsc{time} & \boxed{3} \\ \textsc{loc} & \boxed{4} \end{array}\right] \end{array}\right] \end{array}\right] \end{array}\right] \end{array}\right]$$

Inasmuch as the contextual anchors (see Barwise & Perry (1983) or Devlin (1991) 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*), the time (*now*) and the place (*here*) of speaking.[1] Hence, the CONTEXT attribute accounts for the standard indexical expressions and provides present tense marker needed for a semantic of tenses in the line 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: Sec. 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 in case the surface structures (i.e. strings; see Section 1 on a brief juxtaposition of spoken and

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

written language) are the same. An example is given in (4), taken from Krifka (2008: 246), where capitalisation indicates main accent and subscript "F" labels the focused constituent:

(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, semantic, pragmatic and constituency and hence emphasise in particular the advantages of the *fractal* (Johnson & Lappin 1999) architecture of HPSG (see the sections on Kubota (2018), Chapter 34 of this volume, Borsley & Müller (2018), Chapter 33 of this volume, Müller (2018), Chapter 37 of this volume, Arnold (2018), Chapter **??** of this volume and Hudson (2018), Chapter 36 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* (Heim 2002) and *Discourse Representation Theory* (Kamp & Reyle 1993) to information state update semantics proper (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, 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), where "A-stressed" constituents are coindexed (via structure sharing, see Richter (2018), Chapter 3 of this volume) with FOCUS elements and "B-stressed" are coindexed with LINK elements – see also de Kuthy (2018), Chapter 25 of this volume. The CONTEXT extension for information structure on this account is given in (5):

(5)
$$\begin{bmatrix} \textit{context} & \\ \textsc{c-inds} & [\,] \\ \textsc{backgr} & \{\} \\ \textsc{info-str} & \begin{bmatrix} \textit{info-struc} & \\ \textsc{focus} & \textit{Set(content)} \\ \textsc{ground} & \begin{bmatrix} \textit{ground} & \\ \textsc{link} & \textit{Set(content)} \\ \textsc{tail} & \textit{Set(content)} \end{bmatrix} \end{bmatrix} \end{bmatrix}$$

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 entails, however, that the packages of information structure coincide with syntactic constituents. This assumption is given up in the approach to *prosodic constituency* of Klein (2000) – see also Tseng (2018), Chapter 22 of this volume. Information structure realised by prosodic stress is also part of the speech-gesture interfaces within multimodal extensions of HPSG (cf. Lücking (2018), Chapter 32 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 assumption 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*[2] is due to shared assumptions about the standard meaning of *dog*. Green represents this account in terms of mutual beliefs between EXPERIENCER and STANDARD standard as part of the background condition of the CONTEXT of referential NPs. The semantic part of the lexical structure of *dog* is given in (6). The analysis of proper names is pursued in similar manner, amounting to the requirement that for a successful use of a

[2]Green (1996: Ex. (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 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.

proper name the interlocutors have to know that the intended referent of this name actually bears the name in question.

(6)
$$\begin{bmatrix} \textit{word} \\ \textsc{phon} & \textit{/dog/} \\ \textsc{content} & \begin{bmatrix} \textit{ref} \\ \textsc{index} & \boxed{1} \end{bmatrix} \\ \textsc{context} & \begin{bmatrix} \textit{context} \\ \textsc{c-inds} & \begin{bmatrix} \textit{psoa} \\ \textsc{spkr} & \boxed{2} \\ \textsc{addr} & \boxed{3} \end{bmatrix} \\ \textsc{background} & \left\{ \begin{bmatrix} \textit{mutually-believe} \\ \textsc{experiencer} & \boxed{2} \\ \textsc{standard} & \boxed{3} \\ \textsc{soa} & \begin{bmatrix} \textit{normally-believe} \\ \textsc{experiencer} & \textit{English speakers} \\ \textsc{soa} & \begin{bmatrix} \textit{canis} \\ \textsc{inst} & \boxed{1} \end{bmatrix} \end{bmatrix} \end{bmatrix} \right\} \end{bmatrix} \end{bmatrix}$$

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 2 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 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 baptism, the situationally re-coined termed 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 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 terminology 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"): 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: content of *latest move* made: it is permissible to make whatever moves are available as reactions to the latest move.

Intuitively, turn 2 from question-answer pair in turns 2 and 3 from (8) directly introduces a *question under discussion*. 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 answer receiver 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: Chap. 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 dialogue progressing. This mechanism entails an additional qualification compared to a static mutual belief contexts: 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 the form $\langle \text{DGB} \times \text{MS} \rangle^+$ for each dialogue agent. Here the "Kleene +" indicates 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 (see Cooper & Ginzburg (2015: Sec. 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 is reviewed which mainly consists in inverting the theory's strategic orientation: 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 *clarification request*. Clarification potential plays an important methodological role in the dialogue semantic business, as exemplified in Section 3.1 subsequently.

3 Type-theoretical pragmatics and dialogue semantics

A minimal primer for the rich type theory TTR (a Type Theory with Records) is given in Section 3.3. But why should (dialogue) semantics make use of a type theory at all? Subsequently 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 Sub-sentential meanings: unification 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) A: Did Bo finagle a raise? 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) 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).[3] 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 (2018), Chapter 9 of this volume). In 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 (2018), Chapter 24 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.

[3] 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.

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: Sec. 3); see also Richter (2018), 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 semantics practice in HPSG (cf. Koenig & Richter (2018), Chapter 24 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 a 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 by him 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: Sec. 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 SEM part, which makes them representational signs 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 as 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).

The most popular underspecification mechanism is *(Robust) Minimal Recursion Semantics* (Copestake et al. 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.

The second option, using the type-theoretical framework TTR (a Type Theory with Records), has been developed by Cooper (2008; 2014; 2018) and Ginzburg (2012). TTR, though looking similar to feature structures, directly provides se-

mantic entities, namely types (Ginzburg 2012: Sec. 5.2.2). TTR also has a model-theoretic foundation (Cooper 2018), 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 potentional 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 it at odds with its clarification potential in dialogue. Accordingly, in a series of works a theory of quantified noun phrases (QNPs) have been developed that refrains from type raising and 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) and Cooper (2018)). 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 and needed for intensional readings as figuring in attitude reports such as in Paul

Reilley's question *Is there a scientist who believes that the earth is flat?* posed on quora[4] (see also Cooper (2005a) on attitute 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 and to conclude this chapter, 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 to TTR[5]

TTR (a Type Theory with Records) provides semantic objects at both the token and the type level, structures to organize these objects (viz., records and record types), and (Montagovian) λ-abstraction and functional application (see Cooper (2005b), Cooper (2005a), Cooper (2012), Cooper (2017), and Cooper & Ginzburg (2015) for expositions). The basic notion in TTR is a *judgement* of the form $a : T$, meaning that object a is of type 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 (13), where Fritz the cat sits on mat m33. In order to characterise more complex types, TTR provides *record types*. The record type for the example sentence (ignoring the semantic contribution of the definite article for the sake of exposition[6]) will be (12):

(12)
$$\begin{bmatrix} \text{x} & : & Ind \\ \text{c1} & : & cat(x) \\ \text{y} & : & Ind \\ \text{c2} & : & mat(y) \\ \text{c3} & : & on(x,y) \end{bmatrix}$$

A *witness* for the record type in (12) will be a *record* that provides suitable objects for each field of the record type (and possibly more). A record is a set of fields which consist of assignments from labels to values. The situation depicted

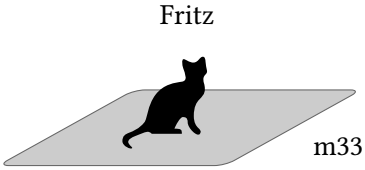
[4] https://www.quora.com/Is-there-a-scientist-who-believes-that-the-earth-is-flat, accessed on October 31, 2018.

[5] The primer is closely related to the one given in Lücking (2018: Sec. 4.1).

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

in (13) can be represented as the record in the left-hand part of (14), where recognition procedures are assumed to be *proofs* for the predicational types from (12). The objects in the fields labelled c1–3 can also be thought of as situations which show Fritz to be a cat, m33 to be a mat and Fritz to be on m33.

(13)



Since the record is of the type required by the record type – which is represented in (14) – the type correctly classifies the situation in question.

(14) $\begin{bmatrix} \text{x} & = & \textit{Fritz} \\ \text{c1} & = & \textit{cat recognition} \\ \text{y} & = & \textit{m33} \\ \text{c2} & = & \textit{mat recognition} \\ \text{c3} & = & \textit{relation recognition} \end{bmatrix} : \begin{bmatrix} \text{x} & : & \textit{Ind} \\ \text{c1} & : & \textit{cat(x)} \\ \text{y} & : & \textit{Ind} \\ \text{c2} & : & \textit{mat(y)} \\ \text{c3} & : & \textit{on(x,y)} \end{bmatrix}$

Although record types will be represented in the above-given format, technically they involve functions from individuals, not labels, to predicational types. That is, officially the "cat part" of the record type in (14) has the following structure:

(15) $\begin{bmatrix} \text{x} & : & \textit{Ind} \\ \text{c1} & : & \langle \lambda v{:}\textit{Ind} \,.\, \textsc{cat}(v), \langle \text{x} \rangle \rangle \end{bmatrix}$

The predicational type c1 from (15) is a function from individuals onto cats, i.e. it is of the Montagovian type $\langle e, t \rangle$, where the object abstracted over is to be found at path x in the record type. This function is characterised by the set of ordered pairs $\{\langle v, \textit{cat}(v) \rangle \mid v : \textit{Ind}\}$ and thereby is linked to a set theoretical notion of extension.

4 Putting things together: HPSG_{TTR} and Dialogue game boards

Signs as construed within HPSG can be reconstructed as record types of a specific kind (Cooper 2008). For instance, (16) shows the record type 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).

(16)
$$\begin{bmatrix} \textsc{phon} & : & \textit{List(PhonType)} & \\ \textsc{synsem} & : & \begin{bmatrix} \textsc{local} & : & \begin{bmatrix} \textsc{cat} & : & \textit{CategoryType} \\ \textsc{content} & : & \textit{SemType} \\ \textsc{context} & : & \textit{SemType} \end{bmatrix} \end{bmatrix} \end{bmatrix}$$

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 descriptive uses as in *The thief (however 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_{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*), dialog 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 (17), where *LocProp* is the type of a *locutionary proposition* (see (19) below) and *poset* abbreviates "partially ordered set".

(17)
$$\begin{bmatrix} \textsc{spkr} & : & \textit{Ind} \\ \textsc{addr} & : & \textit{Ind} \\ \textsc{utt-time} & : & \textit{Time} \\ \textsc{c-utt} & : & \textit{addressing(spkr, addr, utt-time)} \\ \textsc{facts} & : & \textit{Set(Prop)} \\ \textsc{Visualsit} & : & \textit{RecType} \\ \textsc{Pending} & : & \textit{list(LocProp)} \\ \textsc{Moves} & : & \textit{list(LocProp)} \\ \textsc{qud} & : & \textit{poset(Question)} \end{bmatrix}$$

Propositions in TTR can be developed in an explicit Austinian (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". The type of propositions and the relation

to a situation semantics conception of 'true' (Barwise & Perry 1983) is given in (18):

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

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:

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

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 waits for 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)):

(20) $\begin{bmatrix} \textsc{phon} : \textsc{ehh hehh} \\ \textsc{cat} : \begin{bmatrix} \textsc{head} = interjection & : & syncat \end{bmatrix} \\ \textsc{dgb-params} : \begin{bmatrix} \textsc{spkr} & : & Ind \\ \textsc{addr} & : & Ind \\ \textsc{pending} & : & LocProp \\ \textsc{c2} & : & address(spkr,addr,pending) \end{bmatrix} \\ \textsc{cont} = Understand(\textsc{spkr},\textsc{addr},\textsc{dgb-params.pending}) : IllocProp \end{bmatrix}$

Knowing how to use feedback signals such as the one in (20) 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*.

5 Outlook

Given a basic framework for formulating and analysing content in dialogue context, there are various direction 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 a (dialogue) semantic representation has to be developed, but also the rules of their interaction with speech has to be formulated.

- Duologue is the interaction between *two* interlocutors. How can one scale up to *multilogue* (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 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 morphemes and phonemes – that is, processing is incremental (e.g. Sedivy et al. (1999); see also Wasow (2018), Chapter 28 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: A HPSG_{TTR} fragment

The appendix provides a fragment of HPSG_{TTR}. The grammar framework used is oriented at a *Head-driven Phrase Structure Grammar* variant (Sag et al. 2003), respectively 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_{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.

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

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

Structure sharing is indicated by a "tag type" notation. Tag type are defined in terms of manifest fields.[7] The notational convention is exemplified in (22) by means of head-specifier agreement, where the tag type from (22a) abbreviates the structure in (22b):

(22) a. $$\begin{bmatrix} \text{CAT} : \begin{bmatrix} \text{HEAD} : \begin{bmatrix} \text{AGR}\boxed{1} : Agr \end{bmatrix} \\ \text{SPR} : \left\langle \begin{bmatrix} \text{CAT} : \begin{bmatrix} \text{HEAD} : \begin{bmatrix} \text{AGR}=\boxed{1} : Agr \end{bmatrix} \end{bmatrix} \end{bmatrix} \right\rangle \end{bmatrix} \end{bmatrix}$$

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

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

Agr is defined as usual:

(23) $$Agr := \begin{bmatrix} \text{NUM} : Num \\ \text{PERS} : Per \\ \text{GEN} : Gen \end{bmatrix}$$

A basic *sign* is a pairing of phonetic, syntactic and semantic information and follows the geometry in (24):

(24) $$sign := \begin{bmatrix} \text{PHON} : Phoneme \\ \text{CAT} : SynCat \\ \text{DGB-PARAMS} : RecType \\ \text{CONT} : SemObj \end{bmatrix}$$

[7] *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: p. 4, footnote 3).

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:

(25) If dgb-params : R_2 and for two record types R_0 and R_1 lacking any mutual dependencies[8] $R_2 = R_0 \wedge_{merge} R_1$, then R_0 can be moved to q-params, resulting in the following structure:

$$\begin{bmatrix} \textsc{dgb-params} & : & R_1 \\ \textsc{cont} & = & \left[\textsc{q-params} \ : \ R_0\right] \end{bmatrix}$$

A word is a sign with constituent type ("cxtype") *word*. Using the merge operation, the word extension on signs can represented compactly as in (26a), which expands to the structure given in (26b):

(26) a. $word \coloneqq sign \wedge_{merge} \left[\textsc{cxtype} \ : \ word\right] : RecType$

b. $\begin{bmatrix} \textsc{cxtype} & : & word \\ \textsc{phon} & : & Phoneme \\ \textsc{cat} & : & SynCat \\ \textsc{dgb-params} & : & RecType \\ \textsc{cont} & : & SemObj \end{bmatrix}$

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

(27) $lexeme \coloneqq sign \wedge_{merge} \left[\textsc{cxtype} \ : \ lexeme\right] : RecType$

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

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

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

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

(29) a. $hd\text{-}phrase \coloneqq phrase \wedge_{merge} \left[\textsc{dtrs} \ : \ \left[\textsc{hd-dtr} \ : \ Sign\right]\right] : RecType$

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

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

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:

(30) HFP := $\begin{bmatrix} \textsc{cxtype} & : \textit{phrase} \\ \textsc{cat} & : \left[\textsc{head}\boxed{2} : \textit{PoS}\right] \\ \textsc{dtrs} & : \left[\textsc{hd-dtr} : \left[\textsc{cat} : \left[\textsc{head}=\boxed{2} : \textit{PoS}\right]\right]\right] \end{bmatrix}$

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):

(31) PHON := $\begin{bmatrix} \textsc{cxtype} & : \textit{phrase} \\ \textsc{phon} & : \textit{List(/dtrs.hd.dtr/phon, /dtrs.nhd.dtrs/pos1.phon,} \\ & \quad \textit{..., /dtrs.nhd.dtrs/posn.phon)} \end{bmatrix}$

Since semantic composition rests on predication rather than unification, there is no analog to the semantic compositionality principle of Sag et al. (2003) on our account. There is, however, something akin to semantic inheritance: we need to keep track of the contextual resp. quantificational paramaters contributed by the daughters of a phrase. This is achieved in terms of a *dgb-params principle* (*DGBPP*) in (32) which unifies the daughters' dgb-params into the mother's dgb-params (see Ginzburg (2012: 126 *et seq.*) for a similar principle):

(32) DGBPP :=

$$\begin{bmatrix} \textsc{cxtype} & : \textit{phrase} \\ \textsc{dgb-params} & : \begin{bmatrix} /\textsc{dtrs.hd-dtr.dgb-params} \wedge_{\textit{MERGE}} /\textsc{dtrs.nhd-dtrs.pos1.dgb-params} \wedge_{\textit{MERGE}} \\ \ldots \wedge_{\textit{MERGE}} /\textsc{dtrs.nhd-dtrs.pos}\textit{n}\textsc{.dgb-params} \end{bmatrix} \\ \textsc{dtrs} & : \begin{bmatrix} \textsc{hd-dtr} & : \left[\textsc{q-params} : \textit{RecType}\right] \\ \textsc{nhd-dtrs} & : \left\langle \textsc{pos1} : \left[\textsc{q-params} : \textit{RecType}\right], \ldots, \textit{posn} : \left[\textsc{q-params} : \textit{RecType}\right] \right\rangle \end{bmatrix} \end{bmatrix}$$

A headed phrase is well-formed just in case 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:

(33) *hd-phrase* := *hd-phrase* $\wedge_{merge}$ HFP $\wedge_{merge}$ PHON $\wedge_{merge}$ DGBPP

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

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