Chapter 23

Information structure

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Information structure as the hinge between sentence and discourse has been at the center of interest for linguists working in different areas such as semantics, syntax or prosody for several decades. A constraint-based grammar formalism such as HPSG that encodes multiple levels of linguistic representation within the architecture of signs opens up the possibility to elegantly integrate such information about discourse properties. In this chapter, I discuss a number of approaches that have explored how to best integrate information structure as a separate level into the representation of signs. I discuss which lexical and phrasal principles have been implemented in these approaches and how they constrain the distribution of the various information structural features. Finally, I discuss how the various approaches are used to formulate theories about the interaction of syntax, prosody and information structure. In particular, we will see several cases where (word order) principles that used to be stipulated in syntax can now be formulated as an interaction of syntax and discourse properties.

1 Introduction

The *information structure* of a sentence captures how the meaning expressed by the sentence is integrated into the discourse. The *information structure* thus encodes which part of an utterance is informative in which way, in relation to a particular context. A wide range of approaches exists with respect to the question of what should be regarded as the primitives of the information structure.

It is now commonly assumed that there are three basic dimensions of information structure that are encoded in natural languages and that have been assumed as the basic primitives: (i) a distinction between what is new information advancing the discourse (*focus*) and what is known, i.e., anchoring the sentence

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in existing (or presupposed) knowledge or discourse (*background*), (ii) a distinction between what the utterance is about (*topic*, *theme*) and what the speaker has to say about it (*comment*, *rheme*), and (iii) a dimension referred to as *information status* where entities that have already been mentioned in the discourse (*given*) are distinguished from those that have not been mentioned (*new*).[1] For all three ways of partitioning the information structure, we find approaches within the HPSG framework. Example (1) illustrates how one utterance in the context of a question can be structured according to different partitionings of information structure.

(1) Q: What does Sarah drink?

	background		*focus*
A:	Sarah	drinks	TEA.
	topic	*comment*	

The focus/background division with focus as the part of an utterance that is informative with respect to the discourse is one of the most commonly adopted partitionings when studying information structure, and thus many approaches within the HPSG architecture as well assume a division into focus and background, such as the ones that will be discussed in this article: Engdahl & Vallduví 1996, De Kuthy 2002, Webelhuth 2007, Paggio 2009, Bildhauer 2008, Song & Bender 2012 and Song 2017. Less common within the HPSG framework are approaches that take topic, i.e., the material that an utterance is about, as the central notion and assume topic and comment (or theme and rheme) as the primitives of the information structure. Most approaches discussed here assume that the background has one designated (mostly referential) element functioning as the topic (or link), among them Engdahl & Vallduví 1996, De Kuthy 2002, Paggio 2009 and Song 2017.

With respect to information status (including primitives such as new and given mentioned above), the discourse status of referential elements is of interest, i.e., whether they can be linked to previously mentioned items, i.e., whether they are (discourse) old or given, or whether they haven't been mentioned before and are thus (discourse) new. The representation of information status has received comparatively little interest within the HPSG community; the approach by De Kuthy & Meurers 2011 is one of the few that explicitly integrate this dimension into their information structural architecture.

The need to represent discourse properties in a grammar architecture of signs results from the insight that in many, if not all, languages, the way utterances are

[1] For a comprehensive overview of the different research strands with respect to the information structural dimension, see Kruijff-Korbayová & Steedman (2003).

realized via their syntactic structure, morphological patterns and prosody very often interacts with discourse requirements of these utterances. In other words, approaches dealing with constraints on word order in a particular construction need to encode that this particular word order is only grammatical given a particular context, or a particular accent pattern has to be connected to a particular discourse status of the accented elements.[2] Most of the approaches discussed here deal with such interface questions, and I therefore discuss the particular word order and phonetic theories that have been implemented in Sections 6 and 7 in detail. As a starting point, however, I will first discuss the various architectural designs that have been implemented in order to be able to formulate the specific theories integrating discourse constraints.

2 Information structure in the architecture of signs

Several ways of representing information structure within the architecture of signs have been pursued as part of the HPSG framework: one of the earliest approaches, which is similar to the idea of F-marking as pursued in many syntax-based approaches to information structure in Generative Grammar (such as Jackendoff 1972; Selkirk 1982), has been proposed by Manandhar 1994b. He assumes that all signs have an additional appropriate feature INFO-STRUC which takes as its value objects of the sort *info-type*. A sign can then have one of the subtypes of *info-type* shown in Figure 23.1 as its informational marking.

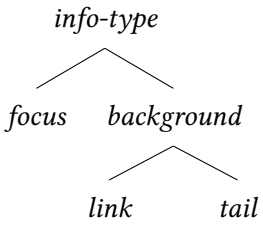


Figure 23.1: Type hierarchy under *info-type* of Manandhar 1994b

The distribution of the INFO-STRUC values in a sign is determined by the *Focus Inheritance Principle*, which enforces that in every phrase, the INFO-STRUC value of the mother subsumes the values of the INFO-STRUC of all of its daughters. The

[2] For some examples in the literature where this has been explored for word order phenomena, see for example Ambridge & Goldberg (2008), De Kuthy & Konietzko (2019) and Culicover & Winkler (2019).

consequence of this principle is that if one daughter in a phrase is in the focus and the other one in the background, then the mother's INFO-STRUC value is the smallest common supertype of both, namely *info-type*.

There are two problematic aspects of such an architecture. Firstly, it leads to a proliferation of syntactic markup of non-syntactic properties, in particular once one considers the full range of information structural notions, such as focus and focus projection, multiple foci and the marking of other discourse functions such as topic. And secondly, the perspective of information structure as resulting from an independent interpretation process of syntactic markup does not support a view of syntax, information structure and intonation as directly interacting modules, a view that can be nicely implemented in a multi-layer framework such as HPSG. More common are thus approaches that encode the information structure as a separate layer, i.e., a feature with its own structural representation.

In the original setup of signs introduced in Pollard & Sag 1994, the feature CONTEXT is introduced as part of *local* objects as a place to encode information relating to the pragmatic context (and other pragmatic properties) of utterances. In Engdahl & Vallduví 1996 it is argued that it would be most natural to also represent information structural information as part of this CONTEXT feature. Engdahl & Vallduví 1996 thus introduce the feature INFO-STRUC as part of the CONTEXT and since they couch their approach into Vallduví's (1992) information packaging account, INFO-STRUC is further divided into FOCUS and GROUND. All INFO-STRUC features take entire signs as their values. The complete specification is shown in (2).

(2) Information structure in Engdahl & Vallduví 1996: 56

$$\begin{bmatrix} \textit{sign} \\ \text{SYNSEM|LOCAL|CONTEXT|INFO-STRUC} \begin{bmatrix} \text{FOCUS} & \textit{sign} \\ \text{GROUND} & \begin{bmatrix} \text{LINK} & \textit{sign} \\ \text{TAIL} & \textit{sign} \end{bmatrix} \end{bmatrix} \end{bmatrix}$$

Another approach locating the representation of information structure within the CONTEXT feature is the one by Paggio 2009 as part of a grammar of Danish. The INFOSTR features TOPIC, FOCUS and BG take as their values lists of indices. Since Paggio 2009 includes Minimal Recursion Semantics (MRS, Copestake et al. 2005) as the semantic representation,[3] these indices can be structure-shared with the argument indices of the semantic relations collected on the RELS list of the content of a sign. The basic setup is illustrated in (3).

[3] A detailed discussion of the properties and principles of MRS as implemented in HPSG can be found in Koenig & Richter (2021), Chapter 22 of this volume.

(3) Information structure in Paggio 2009: 149:

$$\begin{bmatrix} \textit{sign} \\ \textsc{synsem|local|context|infostr} & \begin{bmatrix} \textsc{focus} & \textit{list-of-indices} \\ \textsc{topic} & \textit{list-of-indices} \\ \textsc{bg} & \textit{list-of-indices} \end{bmatrix} \end{bmatrix}$$

Several approaches encode information structure as part of the CONTENT, such as Song 2017 and Song & Bender 2012. Since they also use MRS as the semantic representation language, they enrich the architecture of *mrs* structures. The information structure itself is encoded via a feature ICONS (individual constraints) that is introduced parallel to HCONS (handle constraints) as part of the CONTENT, as shown in (4). Song 2017 and Song & Bender 2012 use *diff-list* as values for the features RELS, HCONS and ICONS (expressed by the "!" at the beginning and the end of the list). This type of list includes an explicit pointer to the last element of the list.

(4) Information structure in Song & Bender 2012 and Song 2017: 116:

$$\begin{bmatrix} \textit{sign} \\ \textsc{synsem|local|content} & \begin{bmatrix} \textit{mrs} \\ \textsc{hook} & \begin{bmatrix} \textit{hook} \\ \textsc{icons-key} & \textit{info-str} \\ \textsc{clause-key} & \textit{event} \end{bmatrix} \\ \textsc{rels} & \textit{diff-list} \\ \textsc{hcons} & \textit{diff-list} \\ \textsc{icons} & \left\langle ! \ldots, \begin{bmatrix} \textit{info-str} \\ \textsc{clause} & \textit{individual} \\ \textsc{target} & \textit{individual} \end{bmatrix}, \ldots ! \right\rangle \end{bmatrix} \end{bmatrix}$$

The type *info-str* used as the value for elements on the ICONS list is divided into an elaborate hierarchy with several subtypes, such as *semantic-focus, constrast-focus, focus-or-topic, non-focus*, etc. (cf. Song 2017: 114). The elements of type *info-str* on the ICONS list have two appropriate features CLAUSE and TARGET. TARGET is always structure-shared with the respective sign's ARG0 value, and the value of CLAUSE is always structure-shared with the INDEX value of the predicate that is the semantic head of the clause.

As pointed out by De Kuthy 2002, assuming that the information structure is part of *local* objects (which it is if it is part of the CONTEXT in HPSG as proposed by Engdahl & Vallduví 1996 or part of the CONTENT) is problematic in connection with a trace-based account of unbounded dependency constructions (UDCs). Traces should not contribute anything to the information structure of a sentence. If one wants to develop an information structure approach which is

independent of the decision of which kind of UDC theory one assumes, the only options for placing the information structure attribute are under *synsem* objects or at the top level.

Information structure as part of *synsem* objects would suggest that it plays a role in syntactic selection. This possibility is assumed in Bildhauer & Cook 2011, and they thus represent INFO-STRUC as a feature appropriate for *synsem* objects (their account will be discussed in more detail in Section 6). A third possibility is argued for in De Kuthy 2002 and Bildhauer 2008, namely that information structure should not be part of *synsem* objects. As a result, they encode information structure again as an additional feature of signs (similar to the approach by Manandhar 1994b discussed above), but it is argued that the appropriate values should be semantic representations. Using indices as the value of information structure-related features (as in the approaches by Paggio 2009, Song & Bender 2012 and Song 2017) is again problematic whenever two constituents share their index value, but only one of them is assigned a particular information structural function. For example, under the assumption that in a head-adjunct phrase the index is structure-shared between an intersective adjective and the nominal head (as in *red car*), there is no way to relate a particular information structure function (e. g., contrast) to the adjective alone (as in *RED car*).

In De Kuthy 2002, a tripartite partition of information structure into focus, topic and background is introduced. As to the question of what kinds of objects should be defined as the values of these features, De Kuthy proposes the values of the INFO-STRUC features to be chunks of semantic information. It is argued that the semantic representation proposed in Pollard & Sag 1994 is not appropriate for her purpose, because the semantic composition is not done in parallel with the syntactic build-up of a phrase. Instead, the Montague-style (cf. Dowty et al. 1981) semantic representation for HPSG proposed in Sailer 2000 is adopted, in which CONTENT values are regarded as representations of a symbolic language with a model-theoretic interpretation. As the semantic object language under CONTENT the language Ty2 (cf. Gallin 1975) of two-sorted type theory is chosen. The resulting feature architecture is shown in (5).

(5) The structure of INFO-STRUC in De Kuthy 2002: 165:

$$\begin{bmatrix} \textit{sign} & \\ \textsc{phon} & \textit{list} \\ \textsc{synsem} & \textit{synsem} \\ \textsc{info-struc} & \begin{bmatrix} \textit{info-struc} \\ \textsc{focus}\ \textit{list-of-mes} \\ \textsc{topic}\ \textit{list-of-mes} \end{bmatrix} \end{bmatrix}$$

The information structure is encoded in the attribute INFO-STRUC that is appropriate for signs and has the appropriate features FOCUS and TOPIC, with lists of so-called meaningful expressions (semantic terms, cf. Sailer 2000) as values. These meaningful expressions (that are also used as the representation of logical forms as the CONT values) are lambda terms formulated in a predicate logic language as discussed in more detail in Section 3.2.2 in (12).

3 Information structure principles

The approaches sketched above all assume that signs contain some kind of structural representation of information structure, with the consequence that they need to introduce principles that constrain the values of the information structural features. Most approaches thus formulate two types of principles as part of their grammar fragment: one set of principles on the lexical level tying information structure to word level properties such as accents, and another set of principles on the phrasal level determining the distribution of information structure values between mother and daughters in a phrase.

3.1 Instantiating information structure on the word level

In the approach of Engdahl & Vallduví 1996, prosodic properties of English, in particular accent placement, are tied to specific information structural properties of words and phrases. On the word level, they thus introduce two principles that instantiate the information structure FOCUS and LINK when the word has a particular accent. The two principles are shown in (6).

(6) Information structure of words (Engdahl & Vallduví 1996: 56):

$$word \Rightarrow \boxed{1} \begin{bmatrix} \text{PHON}|\text{ACCENT} & A \\ \text{INFO-STRUC}|\text{FOCUS} & \boxed{1} \end{bmatrix}$$

$$word \Rightarrow \boxed{1} \begin{bmatrix} \text{PHON}|\text{ACCENT} & B \\ \text{INFO-STRUC}|\text{GROUND}|\text{LINK} & \boxed{1} \end{bmatrix}$$

Words with an A accent always contribute focal information, i.e., the entire sign is structure-shared with the INFO-STRUC|FOCUS value; words carrying a B accent contribute link information, i.e., the entire sign is structure-shared with the INFO-STRUC|GROUND|LINK value.[4]

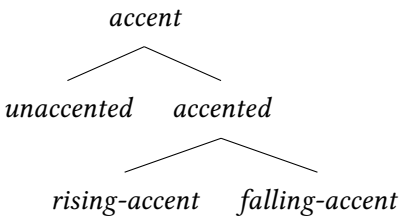
A similar set of word level principles is introduced in the approach of De Kuthy (2002), where the information structure of utterances in German is also tied to

[4]The usage of the terms "A accent" and "B accent" goes back to Jackendoff 1972.

words carrying particular accent patterns. The phonology of signs is altered as shown in Figure 7 to include an ACCENT attribute to encode whether a word receives an accent or not, and whether it is a rising or falling accent, should it receive one.

(7) Representing pitch accents and accent type hierarchy according to De Kuthy (2002: 166):

$$\begin{bmatrix} \textit{sign} \\ \text{PHON} \begin{bmatrix} \text{PHON-STRING} & \textit{list} \\ \text{ACCENT} & \textit{accent} \end{bmatrix} \end{bmatrix}$$



The information structure of words is defined through the principle shown in Figure 8 which assigns the semantic contribution of the word to the focus or topic specification in the information structure representation of that word, depending on the type of accent the word receives.

(8) Principle assigning information structure to words (De Kuthy 2002: 167):

$$\textit{word} \Rightarrow \begin{bmatrix} \text{PHON}|\text{ACCENT} & \textit{falling-accent} \\ \text{SS}|\text{LOC}|\text{CONT}|\text{LF} & \boxed{1} \\ \text{INFO-STRUC} & \begin{bmatrix} \text{FOCUS} & \langle \boxed{1} \rangle \\ \text{TOPIC} & \langle\rangle \end{bmatrix} \end{bmatrix} \vee$$

$$\begin{bmatrix} \text{PHON}|\text{ACCENT} & \textit{unaccented} \\ \text{INFO-STRUC} & \begin{bmatrix} \text{FOCUS} & \langle\rangle \\ \text{TOPIC} & \langle\rangle \end{bmatrix} \end{bmatrix} \vee \ldots$$

Here only two cases are spelled out, one for *falling-accent* signalling focus, and one for unaccented words not contributing anything to the information structure. Other possible cases could for example be a specific accent (like a fall-rise) signalling topic, i.e., a non-empty TOPIC list.

In the approach of Song 2017, lexical items are subtypes of four different *icons-lex-item* types, which specify whether lexical items can contribute any information structural information to the *icons* list, and if yes, how many items can do this. These four lexical subtypes are shown in (9).

(9) Lexical types specifying ICONS values (Song 2017: 137)

a. $\begin{bmatrix} \textit{no-icons-lex-item} \\ \text{MKG} \begin{bmatrix} \text{FC } \textit{na} \\ \text{TP } \textit{na} \end{bmatrix} \\ \text{ICONS } \langle ! \, ! \rangle \end{bmatrix}$

b. $\begin{bmatrix} \textit{basic-icons-lex-item} \\ \text{ICONS } \langle ! \, ! \rangle \end{bmatrix}$

c. $\begin{bmatrix} \textit{one-icons-lex-item} \\ \text{ICONS } \langle ![\ ]! \rangle \end{bmatrix}$

d. $\begin{bmatrix} \textit{two-icons-lex-item} \\ \text{ICONS } \langle ![\ ],[\ ]! \rangle \end{bmatrix}$

Lexical entries for elements that cannot be marked with respect to information structure are of type *no-icons-lex-items*, such as relative pronouns or expletives in English. Nominal items, such as common nouns, proper nouns and pronouns, have lexical entries of type *basic-icons-lex-item*. These types of words can have an information structural marking, but don't have to. The two other lexical subtypes are used for verbs with one clausal argument (*one-icons-lex-item*) or two clausal arguments (*two-icons-lex-items*). The information structural contribution of these clausal arguments then has to be part of the verb's ICONS list. All other verbs are not required to have any elements on their ICONS list and can thus also be of type *basic-icons-lex-item*.

To capture further constraints on the information structure properties on the word level, such as accent patterns triggering focus or topic, lexical rules are formulated in Song 2017 that derive lexical entries with the respective specifications. One such set of lexical rules for A and B accents in English is discussed in Section 7.

3.2 Information structure principles on the phrasal level

3.2.1 Information packaging (Engdahl & Vallduví 1996)

One of the first approaches integrating an explicit representation of information structure into the HPSG architecture, Engdahl & Vallduví 1996 encode the information structure as part of the CONTEXT of signs with the help of an additional feature INFO-STRUC. As discussed above, on the lexical level the instantiation of these features can be triggered by phonetic properties, such as certain accents,

for intonation languages like English. Phrasal signs must then satisfy the INFO-STRUC instantiation constraints in (10).[5]

(10) INFO-STRUC *instantiation principles for English:*
Either (i) if a DAUGHTER's INFO-STRUC is instantiated, then the mother inherits this instantiation (for narrow foci, links and tails),
or (ii) if the most oblique DAUGHTER's FOCUS is instantiated, then the FOCUS of the mother is the sign itself (wide focus).

An example including a wide VP focus licensed by the principle in (10) with the relevant INFO-STRUC values is shown in Figure 23.2.

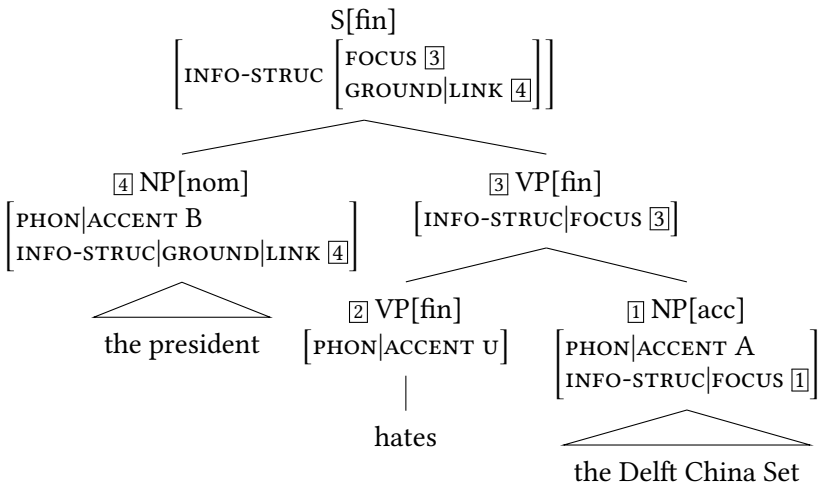


Figure 23.2: An example for VP focus in Engdahl & Vallduví (1996: 59)

In this example, the rightmost NP daughter *the Delft China Set* carries an A accent. According to the principle in (6) shown earlier, the entire sign is thus structure-shared with the focus value (or, in Engdahl & Valluvi's terms, the focus value "is instantiated"). As a consequence, the second clause of the principle in (10) applies and the focus value of the VP mother is the sign itself, which is then inherited by the sentence. Several aspects of the licensing of the structure in Figure 23.2 are not properly spelled out in Engdahl & Vallduvi's approach. For

[5]Engdahl and Vallduví's formulation of the principle is incompatible with the model theoretic view of HPSG in Pollard & Sag 1994. Feature structures are complete models of objects, thus there is no way in which a value can not be instantiated in a feature structure. Only descriptions of feature structures can be underspecified, but not the feature structures themselves.

example, the analysis seems to presuppose a set of additional principles for focus inheritance in nominal phrases which do not straightforwardly follow from the principles formulated in (10).

3.2.2 Information structure as structured meanings (De Kuthy 2002)

The so-called structured meaning approach to information structure (von Stechow 1981; Jacobs 1983; Krifka 1992) provides a compositional semantic mechanism based on separate representations of the semantic contribution of the focus and that of the background. De Kuthy (2002), De Kuthy & Meurers 2003 and Webelhuth 2007 worked out how such a structured meaning approach can be integrated into the HPSG architecture.

As discussed above, in De Kuthy 2002, the information structure is encoded in the attribute INFO-STRUC as part of signs and has the appropriate features FOCUS and TOPIC, with lists of so-called meaningful expressions as values. The background of a sentence in De Kuthy's approach is then defined to be that part of the logical form of the sentence which is neither in focus nor in topic. This characterization of background closely resembles the definition of background employed by the *structured meaning* approach to focus (cf. Krifka 1992). The INFO-STRUC value of a simple sentence with the focus as indicated in (11) is thus structured as shown in (12).

(11) Peter [[liest ein BUCH]]$_F$.
Peter reads a book

(12) A sign representation including information structure (De Kuthy 2002: 163):

$$\begin{bmatrix} \text{S|LOC|CONT|LF} & \exists x[book'(x) \wedge read'(p,x)] \\ \text{INFO-STRUC} & \begin{bmatrix} \text{FOCUS} & \langle \lambda y \exists x[book'(x) \wedge read'(y,x)] \rangle \\ \text{TOPIC} & \langle\rangle \end{bmatrix} \end{bmatrix}$$

The INFO-STRUC values of phrases are constrained by principles such as the one in (13). The original principle formulated in De Kuthy 2002: 169 only contains the first two disjuncts shown in (13). The third disjunct is added in De Kuthy & Meurers 2003. Sentences where the focus or the topic does not project represent the most basic case: only those words bearing an accent are in the topic or in the focus of an utterance.

(13) Principle 1: Extended focus projection principle (De Kuthy & Meurers 2003):

$$
\textit{phrase} \Rightarrow
\left[\begin{array}{l}
\textsc{info-str}|\textsc{focus}\ \boxed{1} \oplus \textit{collect-focus}\left(\boxed{2}\right) \\
\textsc{head-dtr}|\textsc{info-str}|\textsc{focus}\ \boxed{1} \\
\textsc{non-head-dtrs}\ \boxed{2}
\end{array}\right] \vee
$$

$$
\left[\begin{array}{l}
\textsc{phon}|\textsc{phon-str}\ \textit{list} \oplus \boxed{2} \\
\textsc{ss}|\textsc{loc}\left[\begin{array}{l}\textsc{cat}|\textsc{head}\ \textit{noun} \vee \textit{prep} \\ \textsc{cont}|\textsc{lf}\ \ \boxed{3}\end{array}\right] \\
\textsc{info-str}|\textsc{focus}\ \left\langle \boxed{3} \right\rangle \\
\textit{any-dtr}\left(\left[\begin{array}{l}\textsc{phon}|\textsc{phon-str}\ \boxed{2} \\ \textsc{ss}|\textsc{l}|\textsc{cont}|\textsc{lf}\ \ \boxed{4} \\ \textsc{info-str}|\textsc{focus}\ \left\langle \boxed{4} \right\rangle\end{array}\right]\right)
\end{array}\right] \vee
$$

$$
\left[\begin{array}{l}
\textsc{synsem}|\textsc{loc}\left[\begin{array}{l}\textsc{cat}|\textsc{head}\ \textit{verb} \\ \textsc{cont}|\textsc{lf}\ \ \boxed{3}\end{array}\right] \\
\textsc{info-str}|\textsc{focus}\ \left\langle \boxed{3} \right\rangle \\
\textsc{non-head-dtrs}\left\langle \ldots, \left[\begin{array}{l}\textsc{synsem}\left[\begin{array}{l}\textsc{fpp}\ \textit{plus} \\ \textsc{loc}|\textsc{cont}|\textsc{lf}\ \boxed{4}\end{array}\right] \\ \textsc{info-str}|\textsc{focus}\ \left\langle \boxed{4} \right\rangle\end{array}\right], \ldots \right\rangle
\end{array}\right] \vee \ldots
$$

In this case, the mother of a phrase just collects the focus values of all her daughters as ensured by the principle in (13).[6] The relation *collect-focus* ensures that from the list of non-head daughters, the FOCUS value of every non-head daughter is added to the list of FOCUS values of the entire phrase. A similar principle is needed to determine the TOPIC value of phrases.

For cases of so-called focus projection[7] in NPs and PPs, it is assumed in De Kuthy (2002: 169) that it is sufficient to express that the entire NP (or PP) can be focused if the rightmost constituent in that NP (or PP) is focused, as expressed

[6] The presentation differs from that in De Kuthy (2002); it is the one from De Kuthy & Meurers 2003. Definitions of the auxiliary relations:
any-dtr (1):= [HEAD-DTR 1].
any-dtr (1):= [NON-HEAD-DTRS element(1)].
collect-focus(⟨⟩):= ⟨⟩.
collect-focus (⟨[INFO-STRUC|FOCUS ⟨1⟩] | 2⟩):= ⟨1 | *collect-focus*(2)⟩.

[7] Focus projection is a term commonly used to describe the fact that in an utterance with prosodic marking of focus on a word, this marking can lead to ambiguity, in that different constituents containing the word can be interpreted as focused (cf. Gussenhoven 1983; Selkirk 1995).

by the second disjunct of the principle in (13). If focus projection is possible in a certain configuration then this is always optional, therefore the focus projection principle for nouns and prepositions is formulated as a disjunct. The second disjunct of the principle in (13) ensures that a phrase headed by a noun or a preposition can only be in the focus (i.e., its entire logical form is token identical to its FOCUS value) if the daughter that contributes the rightmost part of the phonology of the phrase is entirely focused itself. The relation *any-dtr* is a description of a sign with a head daughter or a list of non-head daughters and thereby ensures that it can be either the head (i.e., head daughter) of the phrase itself, or any non-head daughter that meets the condition of being focused. Again, a similar principle needs to be provided for the TOPIC value of nominal and prepositional phrases.

For the verbal domain, the regularities are known to be influenced by a variety of factors, such as the word order and lexical properties of the verbal head (cf., e.g., von Stechow & Uhmann 1986). Since verbs need to be able to lexically mark which of their arguments can project focus when they are accented, De Kuthy & Meurers 2003 introduce the boolean-valued feature FOCUS-PROJECTION-POTENTIAL (FPP) for objects of type *synsem*. Figure 14 shows the relevant part of the lexical entry of the verb *lieben* 'love' which allows projection from the object but not from the subject:

(14) The focus projection potential of *lieben* (De Kuthy & Meurers 2003):

$$\left[\begin{array}{l}\textsc{phon}|\textsc{phon-str}\ \langle \textsc{lieben} \rangle \\ \textsc{arg-st}\ \left\langle \left[\begin{array}{l}\textsc{loc}|\textsc{cat}|\textsc{head}\ \left[\begin{array}{l}\textit{noun} \\ \textsc{case}\ \textit{nom}\end{array}\right] \\ \textsc{fpp}\ \textit{minus}\end{array}\right], \left[\begin{array}{l}\textsc{loc}|\textsc{cat}|\textsc{head}\ \left[\begin{array}{l}\textit{noun} \\ \textsc{case}\ \textit{acc}\end{array}\right] \\ \textsc{fpp}\ \textit{plus}\end{array}\right] \right\rangle\end{array}\right]$$

The third disjunct of the principle in (13) then specifies under which circumstances focus can project in the verbal domain: a phrase headed by a verb can only be in the focus (i.e., its entire logical form is token identical to an element of its FOCUS value) if the daughter that has the focus projection potential (FPP *plus*) is entirely focused itself.

3.2.3 Information structure principles in MRS

As introduced above, in the MRS based approach of Paggio 2009, the information structure is part of the CONTEXT, consisting of FOCUS, TOPIC and BACKGROUND features which are structure-shared with the respective INDEX values of the semantic representation of a phrase. Paggio 2009 connects the distribution of information structure values to particular clausal types and introduces new phrasal

subtypes which constrain the distribution of information structure in the respective phrase. One such new phrasal subtype is the type *focus-inheritance* as defined in (15), which then has to be cross-classified with every basic phrasal subtype (such as *hd-comp, hd-spec, hd-adj*, etc.) in order to constrain the distribution of focus values across all phrasal subtypes.

(15) Principle for focus inheritance (Paggio 2009: 155):
focus-inheritance ⇒

$$\left[\begin{array}{ll} \textsc{synsem|loc|context} & \left[\begin{array}{ll} \textsc{focus} & \langle \boxed{2}, \boxed{1} \rangle \\ \textsc{bg} & \boxed{3} \end{array}\right] \\ \textsc{hd|synsem|loc|context} & \left[\begin{array}{ll} \textsc{focus} & \boxed{1} \\ \textsc{bg} & \boxed{3} \end{array}\right] \\ \textsc{non-hd} & \left[\begin{array}{ll} \textsc{synsem|loc|context|focus} & \langle \boxed{2} \rangle \\ \textsc{accent} & \textit{true} \end{array}\right] \end{array}\right]$$

The principle in (15) ensures that for signs of type *focus-inheritance*, the list of focus values of the mother is the list of focus values of the head daughter[8] plus the focus value of the non-head daughter, in the case that it is accented. Similar principles are defined for the inheritance of background values, also depending on the accent status of the non-head daughter. Paggio also assumes that each phrasal subtype has further subtypes connecting it to one of the information structure inheritance phrasal types. For example, she assumes that there is a phrasal subtype *focus-hd-adj* that is a subtype both of *hd-adj* and of *focus-inheritance*. Finally, clausal types are introduced that account for the information structure values at the top level of a clause. For example, the specification for *decl-main-all-focus* as shown in Figure 23.3 is a clause in which both the background and the topic values are empty and the mother collects the focus values from the head and the non-head daughters.[9] Different from Paggio's approach, Song & Bender 2012 and Song 2017 locate the representation of information structure within the MRS-based CONTENT value of signs. The list elements of information structural values that are built up for a phrase consist of focus, background or topic elements coindexed with the semantic INDEX values of the daughters of that phrase. The

[8] This is not correctly specified in the original principle as formulated by Paggio (2009). If the head daughter can have a list with more than one element as its FOCUS value, then this entire list would have to be added to the list of FOCUS values of the mother, and not just be one element of that list.

[9] Again, the list specifications as formulated by Paggio (2009) are not entirely correct: if the head daughter's FOCUS value $\boxed{2}$ is a list with more than one element, this list has to be added to the list of FOCUS values of the mother.

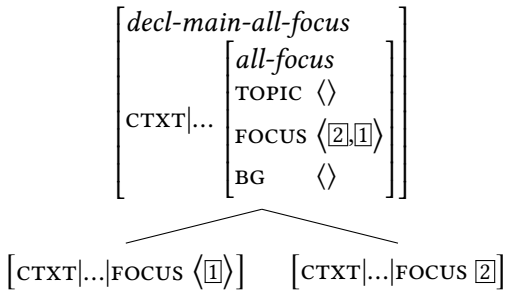


Figure 23.3: Declarative all-focus construction (Paggio 2009: 160)

main point of their approach is that they want to be able to represent underspecified information structural values, since very often a phrase, for example with a certain accent pattern, is ambiguous with respect to the context in which it can occur and thus is ambiguous with respect to its information structure values. An example they discuss is the one in (16), where the first sentence could be an answer to the question *What barks?* and thus signal narrow focus, whereas the second utterance could be an answer to the question *What happened?* and signal broad focus.

(16) a. [[The DOG]]$_F$ barks.
b. [[The DOG barks]]$_F$.

The approach pursued in Song & Bender 2012 thus assumes that the two possible readings in (16) are further specializations of one MRS which is associated with one syntactic structure and includes underspecified values, in particular the type of the ICONS element for the constituent *barks*, leaving it open whether that is part of the focus or not.

In Song 2017, this approach is further spelled out and lexical rules are added that allow transitive and ditransitive verbs to be a possible source for focus projection. In an example such as (17), Song 2017 assumes that focus can only project if the last argument is accented as in (17b) (here accent is shown on the noun *book* in small caps), but not if some other argument is accented, as in (17a), where the proper noun *Lee* is accented.

(17) a. Kim sent LEE the book.
b. Kim sent Lee the BOOK.

Accordingly, there are two lexical entries for the verb *send*, which are derived by the lexical rules shown in (18).

(18) Focus projection lexical rules (Song 2017: 227):

a. *no-focus-projection-rule* ⇒

$$\begin{bmatrix} \textsc{index} & \boxed{1} \\ \textsc{icons-key} & \boxed{2} \\ \textsc{val} & \begin{bmatrix} \textsc{subj} & \left\langle \left[\textsc{icons-key}\ \textit{non-focus} \right] \right\rangle \\ \textsc{comps} & \left\langle \left[\textsc{mkg}|\textsc{fc}\ + \right] \begin{bmatrix} \textsc{mkg}|\textsc{fc} & - \\ \textsc{icons} & \langle !\ ! \rangle \end{bmatrix} \right\rangle \end{bmatrix} \\ \textsc{c-cont}|\textsc{icons} & \left\langle !\ \boxed{2} \begin{bmatrix} \textit{non-focus} \\ \textsc{target}\ \boxed{1} \end{bmatrix} !\right\rangle \\ \textsc{dtr} & \textit{lex-rule-infl-affixed} \end{bmatrix}$$

b. *focus-projection-rule* ⇒

$$\begin{bmatrix} \textsc{clause-key} & \boxed{1} \\ \textsc{val}|\textsc{comps} & \left\langle \begin{bmatrix} \textsc{mkg}|\textsc{fc} & - \\ \textsc{index} & \boxed{2} \end{bmatrix} \begin{bmatrix} \textsc{mkg}|\textsc{fc} & + \\ \textsc{icons} & \langle !\ \left[\textit{semantic-focus} \right] ! \rangle \end{bmatrix} \right\rangle \\ \textsc{c-cont}|\textsc{icons} & \left\langle !\ \begin{bmatrix} \textit{non-focus} \\ \textsc{target}\ \boxed{2} \\ \textsc{clause}\ \boxed{1} \end{bmatrix} !\right\rangle \\ \textsc{dtr} & \textit{lex-rule-infl-affixed} \end{bmatrix}$$

The lexical rule *no-focus-projection-rule* requires lexical entries to have a non-focus-marked element as the last element on the COMPS list, and in addition the word itself has an ICONS-KEY of type *non-focus* preventing the word itself from being focused. The lexical rule *focus-projection-rule* has a focus-marked element as the last element in the COMPS list. It is not further specified whether only that focussed complement or also the word itself contributes anything to the ICONS value. In the example (17b), if the verb *sent* is licensed by the rule *focus-projection-rule*, either only *the book*, or the entire VP *sent Lee the book*, or even the entire sentence *Kim sent Lee the book* could be focused.

Since the approach of Song 2017 is part of a larger grammar fragment (the LinGO Grammar Matrix; Bender et al. 2010) with the aim of parsing and generating sentences from a large number of different languages, it contains a multitude of lexical and phrasal types and principles. Some of these specifications are introduced to capture very language-specific information structure properties (such as morphological markings, word order constraints, etc.), while others are necessary for the specific way in which grammar fragments in the LinGO Grammar Matrix are implemented and processed. It would be far beyond the scope of this article to discuss all these principles and specifications in detail and I therefore only included the most essential aspects of Song's approach in my discussion here.

4 Topics

Most HPSG approaches are based on a focus/background division of the information structure. To capture aspects of a topic vs. comment distinction, or to be able to specify topics as a special element in the background, they include an additional feature or substructure for topics. Engdahl & Vallduví 1996, for example, divide the GROUND into LINK and TAIL, where the link is a special element of the background linking it to the previous discourse, just like topics. In the approaches of De Kuthy 2002 and Paggio 2009, an additional feature TOPIC is introduced, parallel to FOCUS and BACKGROUND, in order to distinguish discourse referents as topics from the rest of the background.

Most approaches don't introduce separate mechanisms for the distribution of TOPIC values, but rather assume that similar principles as the ones introduced for focus can constrain topic values, as mentioned above for the approach of De Kuthy 2002. A more specific example can be found in Paggio 2009, where a constraint on topicalization constructions including a topic-comment partitioning is formulated, as illustrated in Figure 23.4. This *inv-topic-comment* phrasal

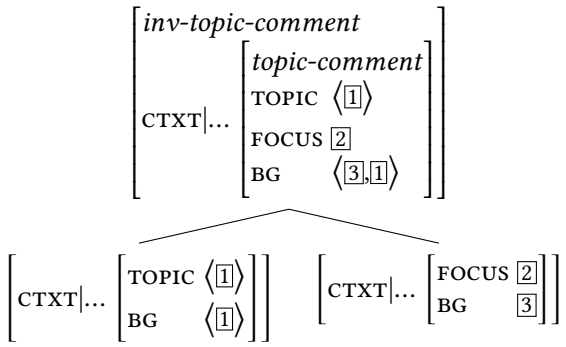


Figure 23.4: Topicalization construction with extracted topic

type constrains the information structure values of topicalization constructions in Danish characterized by subject verb inversion,[10] where the topic corresponds to the topicalized complement, as illustrated by the example in (19) from Paggio 2009.

[10] Although Danish is generally considered to be a V2 language, where any kind of constituent (not only the subject) can occur in the position before the finite verb, Paggio 2009 seems to assume that clauses in which a dependent different from the subject, i.e., an object or some adjunct phrase, occurs before the finite verb have a different structure than those where the subject occurs in the sentence-initial position.

(19) og [i det nederste vindue]$_T$ [tager man og saetter urtepotten]$_F$
and in the lowest window takes one and puts flowerpot.DEF
'And in the lowest window you take and put the flowerpot.'

In Song 2017, a number of lexical and phrasal principles are provided with the purpose of licensing topic-comment structures. The principles and lexical entry in (20) are spelled out in order to license topic-comment constructions in Japanese which are characterized by the occurrence of the topic marker *wa* and a left dislocated topic phrase.

(20) Licensing topic-comment structures in Song 2017:

a. *topic-comment* ⇒
$$\begin{bmatrix} \text{L-PERIPH} & + \\ \text{MKG} & tp \\ \text{HD|MKG|TP} & - \\ \text{NHD} & \begin{bmatrix} \text{MKG} & tp \\ \text{L-PERIPH} & + \end{bmatrix} \end{bmatrix}$$

b. *top-scr-comp-head* ⇒
$$\begin{bmatrix} \text{HA|VAL|COMPS} & \langle\rangle \\ \text{NHD|ICONS-KEY} & \textit{constrast-topic} \end{bmatrix}$$

c. *wa-marker* ⇒
$$\begin{bmatrix} \text{STEM} & \langle wa \rangle \\ \text{INCONS-KEY} & \boxed{2} \\ \text{MKG} & tp \\ \text{COMPS} & \langle [\text{INDEX } \boxed{1}] \rangle \\ \text{INCONS} & \left\langle ! \boxed{2} \begin{bmatrix} \textit{contrast-or-topic} \\ \text{TARGET } \boxed{1} \end{bmatrix} ! \right\rangle \end{bmatrix}$$

The constraint in (20a) on the phrasal subtype *topic-comment* ensures that only the non-head daughter is marked as a topic, whereas the head daughter functions as the comment (and presumably contains some focused material). The specification [L-PERIPH +] indicates that a constituent with this feature value cannot be combined with another constituent leftward.

A Japanese topic-comment structure, such as the one in (21) (Song 2017: 198), is licensed by the phrasal subtype *top-scr-comp-head*, i.e., it is assumed that the fronted complement, the *wa*-marked NP *sono hon wa* 'the book' is scrambled to the left peripheral position and is interpreted as a contrastive topic phrase.

(21) sono hon wa Kim ga yomu.
this book WA Kim NOM read
'This book, Kim read.'

The topic marker *wa* in Japanese is treated as an adposition with the lexical specifications shown in (20c). The entire sentence is thus licensed as a head complement structure, where the object NP is scrambled to the sentence initial position and functions as a contrastive topic. The *tp* marking of the entire *topic-comment* phrase ensures that this phrase cannot be embedded as the comment in another *topic-comment* phrase.

5 Givenness

In De Kuthy & Meurers 2011, it is shown how the HPSG approach to information structure of De Kuthy 2002 and colleagues can be extended to capture givenness and to make the right predictions for so-called *deaccenting*, which has been shown to be widespread (Büring 2006). In contrast to Schwarzschild 1999, who spells out his approach in the framework of alternative semantics (Rooth 1992), they show how the notion of givenness can be couched in a standard structured meaning approach – thereby preserving the explicit, compositional representations of focus.

The example in (22) illustrates the necessity to include information about givenness into the information structural setup.

(22) The conference participants are renting all kind of vehicles. Yesterday, Bill came to the conference driving a red convertible and today he's arrived with a blue one.
   a. What did John rent?
   b. He (only) rented [[a GREEN convertible]]$_F$.

The context in (22) introduces some conference participants, Bill, the rental of vehicles and red and blue convertibles into the discourse. Based on this context, when considering the question (22a) asking for the object that John is renting as the focus, one can answer this question with sentence (22b), where *a green convertible* is the focus: out of all the things John could have rented, he picked a green convertible. In this focus, only *green* is new to the discourse, whereas convertibles were already given in the context, and still the entire NP is in the focus.

To capture such cases of focus projection, an additional feature GIVEN is introduced as part of the setup of De Kuthy 2002, as already discussed in Section 3.2.2. The relation between pitch accents and the information structure of words is still defined by the principle shown in (23), depending on the type of accent the word receives.

(23) Relating intonation and information structure for words (De Kuthy & Meurers 2011):

$$word \Rightarrow \begin{bmatrix} \textsc{phon}|\textsc{accent} & \textit{accented} \\ \textsc{ss}|\textsc{loc}|\textsc{cont}|\textsc{lf} & \boxed{1} \\ \textsc{struc-meaning} & \begin{bmatrix} \textsc{focus} & \langle \boxed{1} \rangle \\ \textsc{given} & \langle\rangle \end{bmatrix} \end{bmatrix} \vee \begin{bmatrix} \textsc{phon}|\textsc{accent} & \textit{unaccented} \\ \textsc{struc-meaning} & \begin{bmatrix} \textsc{focus} & \langle\rangle \\ \textsc{given} & \langle\rangle \end{bmatrix} \end{bmatrix} \vee \ldots$$

In addition, the Focus Projection Principle originally introduced in De Kuthy 2002 and then extended in De Kuthy & Meurers 2003 is extended with a disjunct capturing focus projection in the presence of givenness (De Kuthy & Meurers 2011). Figure 24 shows the resulting principle.

(24) Extended Focus Projection Principle including Givenness (De Kuthy & Meurers 2011):

$$\textit{phrase} \Rightarrow \begin{bmatrix} \textsc{struc-meaning}|\textsc{focus}\ \boxed{1} \oplus \textit{collect-focus}\ (\boxed{2}) \\ \textsc{head-dtr}|\textsc{info-str}|\textsc{focus}\ \boxed{1} \\ \textsc{non-head-dtrs}\ \boxed{2} \end{bmatrix} \vee$$

$$\begin{bmatrix} \textsc{phon}|\textsc{phon-str}\ \textit{list} \oplus \boxed{2} \\ \textsc{ss}|\textsc{loc} \begin{bmatrix} \textsc{cat}|\textsc{head}\ \textit{noun} \vee \textit{prep} \\ \textsc{cont}|\textsc{lf}\ \ \boxed{3} \end{bmatrix} \\ \textsc{struc-meaning}|\textsc{focus}\ \langle \boxed{3} \rangle \\ \texttt{any-dtr}\left(\begin{bmatrix} \textsc{phon}|\textsc{phon-str} & \boxed{2} \\ \textsc{ss}|\textsc{l}|\textsc{cont}|\textsc{lf} & \boxed{4} \\ \textsc{struc-meaning}|\textsc{focus} & \langle \boxed{4} \rangle \end{bmatrix} \right) \end{bmatrix} \vee$$

$$\begin{bmatrix} \textsc{synsem}|\textsc{loc} \begin{bmatrix} \textsc{cat}|\textsc{head}\ \textit{verb} \\ \textsc{cont}|\textsc{lf}\ \ \boxed{3} \end{bmatrix} \\ \textsc{struc-meaning}|\textsc{focus}\ \langle \boxed{3} \rangle \\ \textsc{non-head-dtrs}\ \left\langle .., \begin{bmatrix} \textsc{synsem} & \begin{bmatrix} \textsc{fpp}\ \textit{plus} \\ \textsc{loc}|\textsc{cont}|\textsc{lf}\ \boxed{4} \end{bmatrix} \\ \textsc{struc-meaning}|\textsc{focus} & \langle \boxed{4} \rangle \end{bmatrix}, .. \right\rangle \end{bmatrix} \vee$$

$$\begin{bmatrix} \textsc{ss}|\textsc{loc}|\textsc{cont}|\textsc{lf}\ \boxed{3} \\ \textsc{struc-meaning}|\textsc{focus}\ \langle \boxed{3} \rangle \\ \texttt{dtrs-list}\left(\texttt{given-sign-list} \bigcirc \left\langle \begin{bmatrix} \textsc{ss}|\textsc{l}|\textsc{cont}|\textsc{lf} & \boxed{4} \\ \textsc{struc-meaning}|\textsc{focus} & \langle \boxed{4} \rangle \end{bmatrix} \right\rangle \right) \end{bmatrix} \vee \ldots$$

The new fourth disjunct of the Extended Focus Projection Principle[11] captures the cases previously unaccounted for where given material in a focused phrase is deaccented. Focus in those examples can project from a focused daughter in a position which normally does not allow focus projection. This only is an option if all other daughters in that focused phrase are *given*. Spelling this out, the fourth disjunct of the principle in (24) specifies that the mother of a phrase can be in the focus (i.e., the entire LF value of the mother's CONTENT is token identical to an element on the mother's FOCUS list) if it is the case that the list of all daughters (provided by *dtrs-list*, a relational description of a list containing signs that are given) consists of *given* signs into which a single *focused* sign is shuffled (◯).[12,13] As before, a sign is focused if its LF value is token identical to an element of its FOCUS value; and a sign is given if its LF value is token identical to an element of its GIVEN value.

The pitch accent in this example is on the adjective *green* so that the principle in (8) on p. 1000 licenses structure sharing of the adjective's content with its FOCUS value. In the context of the question (22a), the entire NP *a green convertible* from example (22b) is in the focus. In the phrase *green convertible*, the clause licensing focus projection in NPs does not apply, since the adjective *green*, from which the focus has to project in this case, is not the rightmost element of the phrase. What does apply is the fourth disjunct of the principle licensing focus projection in connection with givenness. Since the noun *convertible* is given, the adjective *green* is the only daughter in the phrase that is not given and focus is allowed to project to the mother of the phrase. In the phrase *a green convertible*, focus projection is again licensed via the clause for focus projection in noun phrases, since the focused phrase *green convertible* is the rightmost daughter in that noun phrase.

[11] The auxiliary relations are defined as:

(i) $\texttt{dtrs-list}(\langle \boxed{1} \boxed{2} \rangle) := \begin{bmatrix} \text{HEAD-DTR} & \boxed{1} \\ \text{NON-HD-DTRS} & \boxed{2} \end{bmatrix}$

$\texttt{given-sign-list} := \langle\rangle.$

$\texttt{given-sign-list} := \left\langle \begin{bmatrix} \text{SS|L|CONT|LF} & \boxed{1} \\ \text{STRUC-MEANING} & \left[\text{GIVEN} \ \langle \boxed{1} \rangle\right] \end{bmatrix} \middle| \ \texttt{given-sign-list} \right\rangle.$

[12] The relation "shuffle" ◯ is used as originally introduced in Reape 1994: the result is a list that contains all element from the two input lists and the order of elements from the original lists is preserved, see also the discussion in Müller (2021: Section 6.1), Chapter 10 of this volume.

[13] If only binary structures are assumed, as in the examples in this chapter, the principle can be simplified. Here, I kept the general version with recursive relations following De Kuthy & Meurers (2003), which also supports flatter structures.

6 Information structure and word order

The explicit representation of information structure as part of signs in HPSG opens up the possibility of providing explanations for constraints previously stipulated in syntax, such as word order constraints, by deriving the constraints from the nature of the integration of a sentence into the discourse. Many of the approaches discussed in the previous section employ the information structural architecture exactly in this way and formulate principles linking word order to discourse properties.

One first such approach is presented in Engdahl & Vallduví 1996, where word order constraints for Catalan are couched into the information structure setup discussed in Section 3.2. The basic observation is that in Catalan, the word order within the sentential core is VOS and that every constituent within this sentential core is interpreted as focal. If an argument of the main verb of a sentence is to be interpreted as non-focal, it must be clitic-dislocated. The example in (25) from Engdahl & Vallduví 1996 illustrates the two possible cases: the argument *a Barcelona* 'to Barcelona' can be topicalized as in (25b) or positioned at the end of the sentence as in (25c) in order to be interpreted as non-focal.

(25) a. Ahir [[va tornar a Barcelona el PRESIDENT]]$_F$.
yesterday returned to Barcelona the president

b. A Barcelona$_1$ [[hi$_1$ va tornar el PRESIDENT]]$_F$.
to Barcelona there returned the president

c. [[Hi$_1$ va tornar el PRESIDENT]]$_F$ a Barcelona$_1$.
there returned the president to Barcelona
'Yesterday, the president returned to Barcelona.'

With respect to modeling this within the HPSG account, they assume that phrases associated with a LINK interpretation should be constrained to be left dislocated, whereas phrases associated with a TAIL interpretation should be right attached. They thus introduce the following ID schema for Catalan:

(26) *Head-Dislocation Schema for Catalan:*
The DTRS value is an object of sort *head-disloc-struc* whose HEAD-DTR|SYNSEM|LOCAL|CATEGORY value satisfies the description $\left[\text{HEAD } \textit{verb} \left[\text{VFORM } \textit{finite}\right], \text{SUBCAT } \langle\rangle\right]$, and whose DISLOC-DTRS|CONTEXT|INFO-STRUC value is instantiated and for each DISLOC-DTR, the HEAD-DTR|SYNSEM|LOCAL|CONTENT value contains an element which stands in a *binding* relation to that DISLOC-DTR.

The principle requires that the information structure value of dislocated daughters of a finite sentence has to be GROUND. An additional LP statement then captures the relation between the directionality of the dislocation and a further restriction of the GROUND value, as illustrated in (27).

(27) LP constraint on information structure in Catalan (Engdahl & Vallduví 1996):

LINK > FOCUS > TAIL

This LP statement is meant to ensure that link material must precede focus material and focus material must precede tails. By this, Engdahl & Vallduví 1996 want to ensure that left-dislocated constituents are always interpreted as links and right-dislocated constituents as tails.

The insights from Engdahl & Vallduvi's approach are the basis for an approach accounting for clitic left dislocation in Greek presented by Alexopoulou & Kolliakou 2002. The representation of information structure with the features FOCUS and GROUND (further divided into LINK and TAIL) is taken over as well as the phonological constraints on words and the information structure instantiation principle. In order to account for clitic left dislocation, as illustrated in (28), an additional feature CLITIC is introduced as appropriate for *nonlocal* objects.

(28) a. Pii simetehoun s' afti tin paragogi?
who take part in that the production
'Who contributed to this production?'

b. Tin parastasi *ti* skinothetise o Karolos KOUN ...
the performance FEM.3SG.ACC directed the Karolos Koun
'Karolos Koun directed the performance ...'

The Linkhood Constraint shown in (29) ensures that links (i.e., elements whose INFO-STRUC|LINK value is instantiated) can only be fillers that are "duplicated" in the morphology by a pronominal affix, i.e., it is required that there is an element 1 on the CLITIC list of the head daughter that is structure-shared with the filler's HEAD value. The use of the disjoint union relation ⊎[14] ensures that the singleton element 1 representing the doubled clitic is the only element on the phrase's clitic list with these specifications. In addition, it is required that the filler-daughter 2 is structure-shared with the LINK attribute in the information structure of the mother.

[14] Alexopoulou & Kolliakou (2002) provide no exact definition for the use of the symbol ⊎ (disjoint union), but a definition that is often used within HPSG approaches can be found in Manandhar (1994a).

(29) The Linkhood Constraint for clitic left dislocation phrases (Alexopoulou & Kolliakou 2002: 238):

$$\begin{bmatrix} \textit{clitic-left-disloc-phrase} \\ \textsc{info-struc}|\textsc{link}\ \{\boxed{2}\} \\ \textsc{clitic}\ \ \boxed{\sum_2} \end{bmatrix} \rightarrow \boxed{2}\begin{bmatrix} \textsc{phon}|\textsc{accent}\ u \\ \textsc{head}\ \ \boxed{1} \end{bmatrix}, \mathbf{H}\begin{bmatrix} \textit{phrase} \\ \textsc{head}\ \ \textit{verb} \\ \textsc{clitic}\ \{\boxed{1}\} \uplus \boxed{\sum_2} \end{bmatrix}$$

The Linkhood Constraint thus has two purposes: it ensures clitic doubling and it connects the particular word order of a left dislocated phrase to discourse properties by requiring the filler daughter to be the link of the entire clause.

Other approaches dealing with left dislocated phrases are the ones by De Kuthy 2002 and De Kuthy & Meurers (2003); the latter relates the occurrence of discontinuous NPs in German to specific information structural contexts, while De Kuthy & Meurers (2003) show that the realization of subjects as part of fronted non-finite constituents can be accounted for based on independent information structure conditions.

Based on the setup discussed in Section 3.2.2 above, constraints are formulated that restrict the occurrence of discontinuous NPs and fronted VPs based on their information structure properties. The type of discontinuous NPs at the center of De Kuthy's approach are so-called NP-PP split constructions, in which a PP occurs separate from its nominal head, as exemplified in (30).

(30) a. *Über Syntax* hat Max sich [ein Buch] ausgeliehen.
about syntax has Max self a book borrowed
'Max borrowed a book on syntax.'

b. [Ein Buch] hat Max sich *über Syntax* ausgeliehen.
a book has Max self about syntax borrowed

The information structure properties of discontinuous noun phrases are summarized in De Kuthy (2002: 176) in the following principle:

> In an utterance, in which a PP occurs separate from an NP, either the PP or the NP must be in the focus or in the topic of the utterance, but they cannot both be part of the topic or the same focus projection. (De Kuthy 2002: 176)

The last restriction can be formalized as: the PP's or NP's CONTENT values cannot be part of the same meaningful expression on the FOCUS list or the TOPIC list of the INFO-STRUC value of the utterance.

As discussed in De Kuthy & Meurers 2003, it has been observed that in German it is possible for unergative and unaccusative verbs to realize a subject as part of a fronted non-finite verbal constituent (Haider 1990a). This is exemplified in (31) with examples from Haider (1990b: 94):

(31) a. [Ein Fehler unterlaufen] ist meinem Lehrer noch nie.
an.NOM error crept.in is my.DAT teacher still never
'So far my teacher has never made a mistake.'

b. [Haare wachsen] können ihm nicht mehr.
hair.NOM grow can him.DAT not anymore
'His hair cannot grow anymore.'

c. [Ein Außenseiter gewonnen] hat hier noch nie.
an.NOM outsider won has hier still never
'An outsider has never won here yet.'

In order to account for the context-sensitive occurrence of such fronted verbal constituents, specific information structure properties of fronted verb phrases need to be expressed in a principle expressing what De Kuthy & Meurers refer to as Webelhuth's generalization (Webelhuth 1990: 53): In an utterance in which a verb phrase occurs as a fronted constituent (i.e., the filler of a head-filler phrase) this entire verb phrase must be in the focus of the utterance (i.e., the FOCUS value of the fronted constituent must be identical to its semantic representation). The formalization of this principle provided by (De Kuthy & Meurers 2003) is shown in (32).

(32) Webelhuth's generalization (De Kuthy & Meurers 2003):

$$\left[\begin{array}{l}\textit{head-filler-phrase}\\ \textsc{non-head-dtr}|\textsc{synsem}|\textsc{loc}|\textsc{cat}|\textsc{head}\ \textit{verb}\end{array}\right] \Rightarrow \left[\begin{array}{l}\textsc{info-struc}|\textsc{focus}\ \langle \boxed{1} \rangle \\ \textsc{non-head-dtr}\ \left[\begin{array}{ll}\textsc{info-struc}|\textsc{focus} & \langle \boxed{1} \rangle \\ \textsc{synsem}|\textsc{loc}|\textsc{cont}|\textsc{lf} & \boxed{1}\end{array}\right]\end{array}\right]$$

Combining the new lexical specifications, the focus projection rule for the verbal domain and the partial fronting focus requirement with the basic setup of De Kuthy 2002, one obtains a theory which predicts that subjects can only be part of a fronted verb phrase if they can be the focus exponent.[15] The sketch of an analysis for an example such as (31c) is illustrated in Figure 23.5. The entry of *gewinnen* 'to win' (the base form of the verb *gewonnen*) in (31c) in (33) encodes the lexical property that the subject of this intransitive verb has focus projection potential.

[15]Not every element in a syntactic phrase corresponding to the focus is prosodically prominent. Generally only one element is: the so-called *focus exponent* (cf. Selkirk 1995).

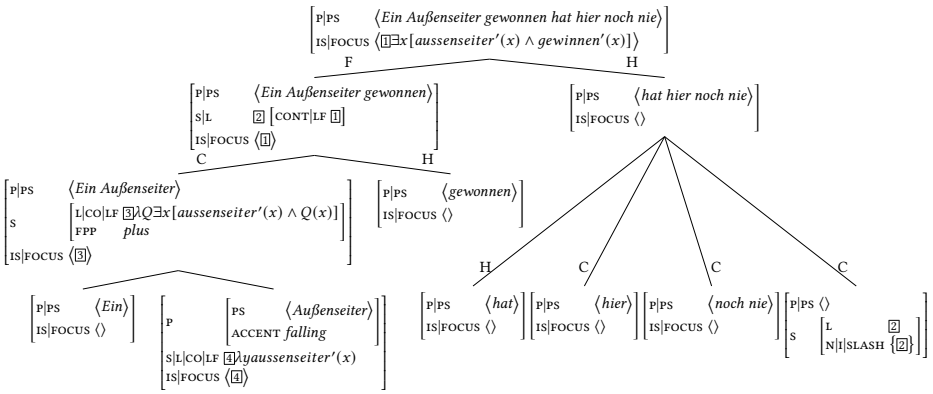


Figure 23.5: Partial VP fronting in De Kuthy & Meurers 2003

(33) The lexical entry of *gewinnen* 'to win':

$$\begin{bmatrix} \textsc{phon} & \langle \textsc{gewinnen} \rangle \\ \textsc{arg-st} & \left\langle \begin{bmatrix} \textsc{fpp} & \textit{plus} \\ \textsc{loc|cat|head|case} & \textit{nom} \end{bmatrix} \right\rangle \end{bmatrix}$$

Under the assumption that in (31c) the noun *Außenseiter* carries a pitch accent, the information structure principle for words in (8) on p. 1000 ensures that the noun contributes its LOGICAL-FORM value to its FOCUS value. The focus projection principle in (13) on p. 1004 ensures that the focus can project over the entire NP *ein Außenseiter*, i.e., its FOCUS element is identical to its LF value. Since *ein Außenseiter* as the subject of *gewonnen* in the tree in Figure 23.5 is lexically marked as FPP *plus*, the principle governing focus projection in the verbal domain in (13) licenses the focus to project over the entire fronted verb phrase *ein Außenseiter gewonnen*. The fronted constituent thus contributes its LF value to its FOCUS value. In this example, the focus does not project further, so that in the head-filler phrase the focus values of the two daughters are simply collected as licensed by the first disjunct of the focus principle in (13) discussed earlier in Section 3.2.2. As a result, the FOCUS value of the fronted verb phrase is the FOCUS value of the entire sentence. Finally, note that the example satisfies Webelhuth's generalization, which requires a fronted verb phrase to be the focus of the utterance as formalized in the principle in (32).

In the same spirit, Bildhauer & Cook 2010 show that sentences in which multiple elements have been fronted are directly linked to specific types of information structure. In German, a V2 language, normally exactly one constituent occurs in

the position before the finite verb in declarative sentences. But so-called multiple fronting examples with more than one constituent occurring before the finite verb have been well attested in naturally-occurring data (Müller 2003). Two examples from Bildhauer & Cook 2010 are shown in (34).[16]

(34) a. [Dem Saft] [eine kräftigere Farbe] geben Blutorangen.
to.the juice a more.vivid colour give blood.oranges
'What give the jiuce a more vivid colour is blood oranges.'

b. [Stets] [einen Lacher] [auf ihrer Seite] hatte die Bubi Ernesto Family.
always a laugh on their side had the Bubi Ernesto Family
'Always good for a laugh was the Bubi Ernesto Family.'

But, as discussed by Bildhauer & Cook, such multiple fronting examples seem to require very special discourse conditions in order to be acceptable. Just like the fronted verb phrases discussed in De Kuthy & Meurers 2003 above, Bildhauer & Cook 2010 propose analyzing multiple fronting constructions in German as head-filler phrases which in this case introduce a topic shift. Following the approach by Müller 2005, multiple fronting configurations can be identified via the filler daughter which must have a HEAD|DSL (double slash) value of type *local*.[17] As introduced above, Bildhauer & Cook 2010 assume that an information structure attribute is specified in *synsem* objects, with the features FOCUS and TOPIC taking lists of *elementary predications* as their values. In general, multiple fronting *head-filler* phrases are restricted by the constraint in (35).

(35) Relating multiple fronting to focus (Bildhauer & Cook 2010: 75):

$$\left[\begin{array}{l} \textit{head-filler-phrase} \\ \textsc{non-head-dtrs} \left\langle \left[\textsc{loc|cat|head|dsl}\ \textit{local}\right] \right\rangle \end{array}\right] \Rightarrow \left[\textsc{is}\ \textit{pres} \vee \textit{a-top-com} \vee \ldots\right]$$

$$\left[\begin{array}{l} \textit{head-filler-phrase} \\ \textsc{is}\ \textit{pres} \end{array}\right] \Rightarrow \left[\begin{array}{l} \textsc{ss|loc|cat|head|dt} \left\langle \left[\textsc{loc|cont|rels}\ \boxed{1}\right] \right\rangle \\ \textsc{hd-dtr|ss|is|focus}\ \left\langle \boxed{1} \right\rangle \end{array}\right]$$

[16] The examples are corpus examples that were extracted by Bildhauer & Cook 2010 from Deutsches Referenzkorpus (DeReKo), hosted at the Institut für Deutsche Sprache, Mannheim: http://www.ids-mannheim.de/kl/projekte/korpora

[17] In Müller's (2005) formalization, filler daughters in multiple fronting configurations (and only in these) have a HEAD|DSL value of type *local*, i.e., they contain information about an empty verbal head. The DSL ('double slash') feature is needed to model the HPSG equivalent of verb movement from the sentence-final position to initial position.

The first constraint ensures that *head-filler* phrases that are instances of multiple frontings are restricted to have an IS-value of an appropriate type.[18] The second constraint then ensures that in presentational multiple frontings, the designated topic of the head daughter (i.e., the verbal head of the *head-filler-phrase*) must be focused. The feature DT (designated topic) lexically specifies which element, if any, is normally realized as the topic of a particular verb. This constraint thus encodes what Bildhauer & Cook 2010 call "topic shift": the non-fronted element in a multiple fronting construction that would preferably be the topic is realized as a focus. A similar constraint is introduced for another instance of multiple frontings, which is called *propositional assessment* multiple fronting. Here it has to be ensured that the designated topic must be realized as the topic somewhere in the head daughter and the head daughter must also contain a focused element.

Webelhuth 2007 provides another account of the special information structural requirements of fronted constituents, in this case of predicate fronting in English that is based on the interaction of word order and information structural constraints.

(36) I was sure that Fido would bark and *bark he did*.

The principles that are part of Webelhuth's account require that in such cases of predicate fronting, the auxiliary is focused and the remainder of the sentence is in the background. The two principles needed for this interaction are shown in (37).

Second constraint seems redundant since hd-fill-ph could be a supertype of pred-prepos-ph

(37) Predicate preposing phrases (Webelhuth 2007):

$$\begin{bmatrix} \textit{aux-wd} \\ \text{ARG-ST} \ \langle \text{NP, gap-ss} \rangle \end{bmatrix} \Rightarrow \begin{bmatrix} \text{SS|STATUS} \ \textit{foc} \\ \text{ARG-ST} \quad \langle \begin{bmatrix} \text{STATUS} \ \textit{bg} \end{bmatrix}, \text{GAP-SS} \rangle \end{bmatrix}$$

$$\textit{pred-prepos-ph} \Rightarrow \begin{bmatrix} \textit{hd-fill-ph} \\ \text{NON-HD-DTR} \ \begin{bmatrix} \text{SS|STATUS} \ \textit{bg} \end{bmatrix} \end{bmatrix}$$

The first constraint ensures that auxiliary words whose predicate complement has the potential to be preposed (i.e., is of type *gap-ss*) have the information status *focus*, whereas the status of the first argument (the subject) is *background*. Additional constraints then ensure that auxiliary words with a gapped second

[18] Bildhauer & Cook 2010: 75 assume that the type *is* as the appropriate value for IS has several subtypes specifying specific combinations of TOPIC and FOCUS values, such as *pres* for presentational focus or *a-top-com* for assessed topic-comment.

argument can only occur in predicate preposing phrases, and vice versa, that predicate preposing phrases contain the right kind of auxiliary.

7 Information structure and prosody

A lot of languages mark information structure prosodically, like for example English and German, where pitch accents of various shapes are used to mark focus. Accordingly, several of the approaches discussed above include a component which enriches the phonology representation of signs such that it allows the integration of the necessary prosodic aspects like accents.

Engdahl & Vallduví 1996 assume that signs can be marked for particular accents signaling focus or links in English, so-called A and B accents. In a similar way, De Kuthy 2002 extends the value of PHON such that it includes a feature ACCENT, in order to formulate constraints on the connection between accents and information structure markings. Most of approaches discussed above do not include a detailed analysis of the prosodic properties of the respective language that is being investigated with respect to discourse properties. As a result, most approaches do not go beyond the postulation of one or two particular accents, which are then somehow encoded as part of the PHON value. These accents more or less serve as an illustration of how lexical principles can be formulated within a particular theory that constrains the distribution of information structural values on the lexical level. The more articulate such a representation of PHON values including accent pattern, intonation contours, boundary tone, etc. is, the more detailed the principles could be that are needed to connect information structure to prosodic patterns in languages that signal discourse properties via intonation contours.

In Bildhauer 2008, one such detailed account of the prosodic properties of Spanish is developed together with a proposal for how to integrate prosodic aspects into the PHON value, also allowing a direct linking of the interaction of prosody and information structure. In his account, the representation of PHON values in HPSG is enriched to include four levels of prosodic constituency: phonological utterance, intonational phrases, phonological phrases and prosodic words. The lowest level, prosodic words of type *pwrd*, include the feature SEGS, which corresponds to the original PHON value assumed in HPSG, and additional features such as PA for pitch accents or BD for boundary tones, which encodes whether a boundary tone is realized on that word. The additional features UT (phonological utterance), IP (intonational phrase) and PHP (phonological phrase) encode via the typ *epr* (edges and prominence) which role a prosodic word plays

in higher level constituents. For example, the feature DTE (designated terminal element) specifies whether the word is the most prominent one in a phonological phrase. A sign's PHON list then contains all *pwrd* objects, and relational constraints define the role each prosodic word plays in the higher prosodic constituents. This flat representation of prosodic constituency still makes it possible to express constraints about intonational contours associated with certain utterance types. One example discussed in Bildhauer's work is the contour associated with broad focus declaratives in Spanish, which can be decomposed into a sequence of late-rise (L*H) prenuclear accents, followed by an early-rise nuclear accent (LH*), followed by a low boundary tone (L%). The constraint introduced to model this contour for declarative utterances thus instantiates the BD value (boundary tone) of the last *pwrd* (prosodic word) in the PHON list to *low*, instantiates a nuclear pitch accent *low-high-star* on this rightmost prosodic word and ensures that a prenuclear pitch accent *low-star-high* is instantiated on every preceding compatible prosodic word. The constraint encoding this is shown in (38).

What about the ↔?

(38) Intonational contour of Spanish declarative utterances (Bildhauer 2008: 142):

$$\begin{aligned} \textit{decl-tune}(\boxed{1}) \leftrightarrow \boxed{1} = \boxed{2} \oplus \left\langle \begin{bmatrix} \textsc{pa} & \textit{low-high-star} \\ \textsc{bd} & \textit{low} \end{bmatrix} \right\rangle \wedge \\ \boxed{2} = \textit{list}\left(\begin{bmatrix} \textsc{bd} & \textit{none} \end{bmatrix} \right) \wedge \\ \boxed{2} = \textit{list}\left(\begin{bmatrix} \textsc{pa} & \textit{none} \end{bmatrix} \right) \bigcirc \textit{list}\left(\begin{bmatrix} \textsc{pa} & \textit{low-star-high} \end{bmatrix} \right) \end{aligned}$$

$$\begin{bmatrix} \textit{sign} \\ \textsc{embed} & - \end{bmatrix} \Rightarrow \begin{bmatrix} \textsc{phon} & \boxed{1} \end{bmatrix} \wedge \textit{decl-tune}(\boxed{1})$$

The second constraint in (38) ensures that only unembedded utterances can be constrained to the declarative prosody described above. That this specific contour is then compatible with a broad focus reading is ensured by an additional principle expressing a general focus prominence constraint for Spanish, namely that focus prominence has to fall on the last prosodic word in the phonological focus domain, which, in the case of a broad focus, can be the entire utterance. The principle formulated in Bildhauer's account is shown in (39).

(39) Focus prominence in Spanish (Bildhauer 2008: 146):

$$\begin{bmatrix} \textit{sign} \\ \textsc{cont} & \boxed{1} \\ \textsc{foc} & \boxed{1} \end{bmatrix} \Rightarrow \begin{bmatrix} \textsc{phon} & \textit{list} \oplus \left\langle \begin{bmatrix} \textsc{ut}|\textsc{dte} & + \end{bmatrix} \right\rangle \end{bmatrix}$$

Since only words that are the designated terminal element (DTE) can bear a pitch accent, the interplay of the two principles above ensures that in utterances with a declarative contour the entire phrase can be in the focus. These principles thus illustrate nicely not only how lexical elements can contribute to the information structure via their prosodic properties, but also how entire phrases with specific prosodic properties can be constrained to have specific information structural properties.

The approach of Song 2017 also includes a component that captures the interaction between prosodic properties of utterances and the effect on the information structure. In order to include information structural constraints of the so-called A and B accents in English, several components of Bildhauer's (2008) phonological architecture are adapted for the information structural setup in Song 2017. Among them is the idea that in a phonological phrase (encoded in the feature phonological utterance UT), focus prominence is related to the most prominent word in that phrase, which is encoded via the constraint in (40).

(40) Prosodic marking of focus (Song 2017: 159):

$$\textit{lex-rule} \Rightarrow \begin{bmatrix} \text{UT}|\text{DTE}\ \boxed{1} \\ \text{MKG}|\text{FC}\ \boxed{1} \end{bmatrix}$$

Specific lexical principles for the A and B accents then ensure the correct information structural marking and specifiy which type of element has to be present on the ICONS list. The specification necessary for English A accents that signal focus (here characterized as *high-star*) are shown in (41).

(41) Focus marking of A accents in English (Song 2017: 160):

$$\textit{fc-lex-rule} \Rightarrow \begin{bmatrix} \text{UT}|\text{DTE} & + \\ \text{PA} & \textit{high-star} \\ \text{MKG} & \textit{fc-only} \\ \text{INDEX} & \boxed{1} \\ \text{INCONS-KEY} & \boxed{2} \\ \text{C-CONT}|\text{ICONS} & \left\langle\, !\, \boxed{2} \begin{bmatrix} \textit{semantic-focus} \\ \text{TARGET}\ \boxed{1} \end{bmatrix} !\, \right\rangle \\ \text{DTR}|\text{HEAD} & \textit{+nv} \end{bmatrix}$$

8 Conclusion

I have discussed various possibilities for how to represent information structure within HPSG's sign-based architecture. Several approaches from the HPSG literature were presented which all have in common that they introduce a separate

feature INFO-STRUC into the HPSG setup, but they differ in (i) where they locate such a feature, (ii) what the appropriate values are for the representation of information structure and (iii) how they encode principles constraining the distribution and interaction of information structure with other levels of the grammatical architecture. Finally, I discussed a number of theories in which phenomena such as word order are constrained to only be well-formed when they exhibit specific information structural properties.

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Part IV

Other areas of linguistics