Formal & Computational Aspects of

Dependency Grammar

– Argument structure in DG –

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Goals

- Today we will have a look at two levels of argument structure, namely **subcategorization** and **valency**.
- At each level, we look at argumenthood from different viewpoints:
  - *Role of dependency*: heads and dependents, types of relations, the meaning of relations.
  - *Different dimensions of 'argumenthood'*: obligatoriness versus optionality, core versus free modification.
  - *Instantiations* of these notions in various dependency- and phrase structure-grammar frameworks.
- We argue that subcategorization and valency describe *distinct* levels of structure in a grammar.
  - We examplify why these levels are not isomorphic.
  - We develop a *typological theory of abstract case* to relate them.

Contents

Subcategorization and valency

- **Grammar** is the description of how (well-formed) surface structures relate to an underlying meaning (as far as linguistically realizable).
- We distinguish **subcategorization** from **valency**:
  - Subcategorization describes a head's argument structure at the level of surface structure.
  - Valency describes a head's argument structure at the level of linguistic meaning.
- Why distinguish the two?
  - Various authors have assumed they are isomorphic, cf. for example (Oehrle, 1994; Moortgat, 1997).
  - However, subcategorization and valency are *not* isomorphic.

Subcategorization and valency are not isomorphic

- Arguments for why subcategorization ("syntax") and valency ("semantics") are not isomorphic:
- **Expletive pronouns** may be syntactically required, but they have no meaning (and hence no corresponding argument in a valency frame).

  (1) a. German *Es gibt einen Student im Kino*
  "There is a student in the cinema"
  b. Compare *It rains* with Latin, *Pluit*.

  Cf. (Sgall et al., 1986; Pollard and Sag, 1993; Jacobson, 1990).
- **Relational nouns** are nouns that have arguments at the level of meaning which do not need to be subcategorized for (in order to yield well-formed expressions).

  (2) The (family) meaning of *brother* necessarily includes a "relation" *brother-of*, possibly even *son-of*.

Subcategorization and valency are not isomorphic

- **Raising verbs** provide another possible argument: Various frameworks give an account of raising in which syntactic types do not correspond isomorphically to semantic structure.
  - In traditional raising theories, the raising verb denotes a 1-place relation that only takes a proposition as its argument. Hence there needs to be a "deep subject" for the argument VP that gets moved.
  - In the *lexical entailment theory of raising* (Chierchia, Dowty,...) a raising verb denotes a relation between individuals (subjects) and properties. Control is done through lexical entailment.
  - Like LE raising, Jacobson (1990) rejects movement and deep subjects, but accepts there being a mismatch between syntactic and semantic type (unlike LE raising). Consequently, Jacobson can then model control and composition directly in the syntax, using functional composition.
- The non-isomorphism has several consequences.

Consequences of non-isomorphy

- If we have an isomorphism, then subcategorization is directly derivable from valency.
- Consequently, syntactic structure is really just an artefact, it is just a means to get to the underlying meaning. Subcategorization has no status independent of valency (Moortgat, 1988; Oehrle, 1994; Morrill, 1997).
- **Strong compositionality**: Technically, we can construct a Curry-Howard isomorphism between syntactic derivation (proofs) and semantic representation (λ-terms).
- But if subcategorization and valency are not isomorphic, then matters become a bit more involved ...
- We construct a *linking theory* between subcategorization and valency. Here we argue how that in fact leads to nice cross-linguistic generalizations.
- Compositionality is not lost! See for example (Kruijff, 2001b; Baldridge and Kruijff, 2002).

Remarks on subcategorization in DG

- Two important aspects of subcategorization (ingredients of a **subcategorization frame**): Argumenthood and order.
- *Argumenthood*: When is an argument *necessary* for wellformedness?
- Yet, we must not mistake function/argument structure for head/dependent structure!
  - From a functional (categorial) perspective, one has to distinguish *function/argument* structure from head/dependent structure: Venneman (1977) equates the two, but this is wrong (Hawkins, 1983; Kruijff, 2001b).

Remarks on subcategorization in DG

- Consider the slashes $\{\backslash, /\}$ to bear an indication of *dependency* $\prec, \succ$ pointing from head to dependent

  (3) a. $John \vdash NP$
  b. $walks \vdash NP \backslash_{\prec} S$

- $John \vdash NP + walks \vdash NP \backslash_{\prec} S$ gives us $(John \circ_{\prec} walks) \vdash S$, with $John$ as a dependent of $walks$.
- For an adverb we don't use $S \backslash S$, but use $S \backslash_{\succ} S$ instead.
  - The adverb is the function, taking the verb as an argument.
  - But, the dependency shows that the adverb is the dependent, and the verb being composed with is the head of the construction.

Remarks on subcategorization in DG

- *Order* of arguments in a head's subcategorization frame: Well-formedness includes proper linearization, but what does the ordering of arguments describe?
- The ordering can be done according an *obliqueness hierarchy* :
  - HPSG (Pollard and Sag, 1987) employs Keenan & Comrie's (1977) obliqueness hierarchy.
  - Functional Generative Description (Sgall et al., 1986) uses the Praguian notion of systemic ordering (Panevová, 1974; Sgall et al., 1986; Sgall et al., 1995).
- Naturally, the order can also describe (canonical) surface word order.

Between subcategorization and surface word order

- Using an obliqueness hierarchy or systemic ordering does not provide a full account of word order.
- But what *would*?
  - In PSG, phrase structure provides the scope for linear precedence, or word order domains.
  - In DG, we have no phrases, only lexical nodes ...
- With (Bröker, 1998) we can therefore ask, "can DG capture word order phenomena without recourse to phrasal nodes, traces, slashed categories etc"?
- From the investigation of this larger issue, 'the' notion of subcategorization proper to DG will arise.

Surface word order in DG

- Adopting a middle ground: combining (flexible) constituency and dependency grammar, e.g.:
  - Categorial-grammar based, e.g. Venneman (1977), Milward's dynamic dependency grammar, (1992; 1994; 1995) or Kruijff's Dependency Grammar Logic (1997; 1999; 2001b; 2001a).
  - Based on Tree-Adjoining Grammar, e.g. Joshi, Rambow and Becker; Rambow, Weir, and Vijayashanker (2001)
  - Gerdes and Kahane (2001).
- Modelling word order purely in terms of dependency relations and constraints on their configuration, e.g.:
  - Bröker's modal-logical interpretation of dependency grammar (1997; 1998).
  - Duchier and Debusmann's (2001) Topological Dependency Grammar.

  We discuss these theories in more detail in the lecture on Friday.

Surface word order in DG

- It needs to be said though that, aside from Bröker and Duchier & Debusmann, there are very few proper 'pure' accounts around.
- Mel'čuk's Meaning-Text Theory and Sgall et al's Functional Generative Description lack complete formal descriptions of the transduction steps they presume.
  - For MTT, see (Mel'čuk and Pertsov, 1987)(p.187ff).
  - The formal description that (Machová, 1977) gives for FGD is based on PSG.
- Hudson's Word Grammar (1984; 1990) does provide an account of word order, but e.g. Bröker argues the account is inconsistent (1997; 1998)
- Other accounts, like Covington (1990), McCord's Slot Grammar, Hellwig's Dependency Unification Grammar, or Temperley, Sleator & Lafferty's Link Grammar all rely heavily on a *parser* to solve word order.

Separating dependency and linearization

- The basic ideas in both Bröker and Duchier & Debusmann are to
  - Represent constructions purely in terms of dependency relations (immediate, binary relations), resulting in *labelled trees*.
  - Specify linearization constraints directly over dependency relations rather than over phrases, using a notion of 'fields' or *word order domain* as formalized earlier by Reape (1994).
  - Note: Both approaches deal with German!
- Bröker employs modal logic to construct tree descriptions, after (Blackburn, 1994). Duchier & Debusmann use constraints, after (Duchier, 1999).
- What both approaches result in is a separation of dependency from linearization.
  - Recall Tesnière's *l'ordre structurel* and *l'ordre linéaire*.
  - Same in e.g. GPSG: We get separate trees for Immediate Dominance and Linear Precedence.

Separating dependency and linearization

- Dependency helps introducing domains, but the constraints on linearization are formulated without recourse to dependency as such. (This contrasts with e.g. Reape's approach, which still refers to phrasal nodes.)
- In Duchier & Debusmann this leads to two separate tree structures, the ID-trees and the LP-trees.
- Furthermore, lexicalization (Duchier and Debusmann, 2001) leads to the specification of two separate *syntactic* argument structures: a subcategorization frame purely for dependency ($\mathsf{valency}_{ID}$), and a subcategorization frame purely for linearization ($\mathsf{valency}_{LP}$).
- Similarly, Bröker has a dependency tree and a separate dimension of order domains.

Resulting notions of subcategorization in DG

- Hence, if we take a purely dependency-based approach, whether lexicalized (Duchier & Debusmann) or rule-based (Bröker), subcategorization information gets split up into two separate (though mutually constraining) dimensions: dependency and linear precedence.
- Compare this to (Penn, 1999)'s proposal for HPSG, letting different dimensions (like syntactic constituency DTRS) mutually constrain each other through DOM.
- Alternatively, both dependency and linearization can be combined into a single tree-structure, like in (Kruijff, 2001b), and lead consequently to a single subcategorization frame.
- A single tree-structure might have the advantage that one can directly refer to semantically-motivated dependency relations (e.g. for coordination, clitic placement (Avgustinova and Oliva, 1995)) – Duchier & Debusmann have separate sets of relations for $\mathsf{valency}_{ID}$ and $\mathsf{valency}_{LP}$.

Valency

- Valency describes a head's argument structure at the level of linguistic meaning.
- This looks like a *predicate-argument structure*, but there are fundamental differences (Dowty, 1989).
- In a first-order logic/λ-calculus based representation of predicate-argument structure, the meaning of an argument is normally determined/reflected by its *position* in the predicate.

  (4) $\lambda x.\lambda y.\lambda z.read(x, y, z)$
  x = reader, y = object being read, z = object/person being read to.

- In a dependency-based view on linguistic meaning, the meaning of an argument is indicated by its *role*.

  (5) $read(Actor : x, Patient : y, Addressee : z)$

Valency (cont'd)

- Not only do we *label* arguments differently, there are additional dimensions to roles.
- Within a valency frame, roles can naturally be *obligatory* or *optional*.
- Independent of a specific frame, a role is classified as a *core modification* (≤ 1) or *free modification* (≥ 0).
- For each role, we can specify its *interpretative import* – what does it *mean* to interpret a dependent as being of a particular type?

Roles and question tests

- With respect to modification at the level of meaning, we can ask two questions (Panevová, 1974):
  1. Does the head *have* to be modified by a dependent of type X (X is *obligatory*), or not (X is *optional*)?
  2. Can the head have *exactly one* dependent of type X (X is a *core modifier*) or several dependents of type X (X is a *free modifier*)?
- To establish obligatoriness/optionality and core/free modification, various authors have proposed *tests*.
  - In the German tradition for example Bierwisch, Helbig, Heringer, Herbst (cf. e.g. (Allerton, 1994)).
  - In the Prague School see primarily Panevová (1974; 1975; 1980; 1994).

Roles and question/dialogue tests

- At least the following two questions are normally used to establish core/free modification (Panevová, 1994):

  1. "Do the rules of the language described allow for the occurrence of the given modification with every verb?"
  2. "Can the modification occur more than once depending on a single verb token?"

Relation	Question 1	Question 2
Actor	yes (?)	no
Patient	no	no
Time:When	yes	yes

  Ad ?: Does a verb like *rain* have a "general Actor"?

- Tesnière distinguises *actants* from *circonstants*, Sgall et al talk of *inner participants* versus *free modifiers*, and German linguists often discern *Ergänzungen* from *freie Angaben*.

Roles and question/dialogue tests

- For establishing obligatoriness of a dependent, Panevová specifies a *dialogue test* that revolves around the question whether a dependent can be elided in the surface form.
  - If a speaker uses ellipsis, the underlying assumption is that the speaker knows the elided material, and that the hearer can easily recover it.
  - A dependent is obligatory if a negative answer concerning the elided material (the speaker doesn't know) would disturb the dialogue.

(6) (A.) "Peter arrived."

(7) (B.) "Whereto?"
(A.) "I don't know."

(8) (B.) "When?"
(A.) "I don't know."

- The valency frame for *arrive* has **Dir:WhereTo** as obligatory modification, but not **Time:When**.

Roles and their meaning

- What *kinds* of roles do people employ?
- **Grammatical functions**
  - Roles are grammatical functions like Subject, Direct/Indirect Object.
  - Meaning-Text Theory (Mel'čuk, 1988), LFG's f-structure (Bresnan, 2001), Topological Dependency Grammar (Duchier and Debusmann, 2001).
- **Functional relations**
  - Thematic/θ-roles, dependency relations,... that express aspects of meaning but that (arguably) can be distinguished through different syntactic behavior, and are thus primarily *linguistic*.
  - Praguian structuralist-functionalist tradition: Functional Generative Description (Sgall et al., 1986), Dependency Grammar Logic (Kruijff, 2001b).
  - Government & Binding (Haegeman, 1991).

- **Conceptual/cognitive relations**:
  - Fillmore's Case grammar, Hudson's Word Grammar (1984), Bröker's interface to knowledge representations (Bröker, 1997).

Roles and their meaning

- What does it mean for a dependent to be of a particular kind? What do *roles* mean?
- Influence on **inheritance** in a conceptual structure, cf. Word Grammar.
- **Interpretative import** (Kruijff, 2001b): The kind of relation along which a dependent modifies a head determines *how* the dependent's meaning contributes to the head's meaning. 'Contribution' can mean:
  - *further specification* (e.g. location)
  - *coercion* (e.g. aspectual coercion, (Dowty, 1979; Kruijff, 2001b), or temporal coercion).

  We'll see more on interpretative import in Thursday's lecture!
- The meaning of a dependency relation is a composition of **primitive features**, cf. (Panevová, 1994; Sgall et al., 1996) or Dowty's proto-roles.

Relating subcategorization and valency

- If grammar describes the relation between form and meaning, then (particularly in a lexicalized setting) this revolves around *linking* subcategorization and valency.
- We need to be able to address, how functional relations get realized, and how we can recognize a wordgroup's function from its "form".
- The realization of functional relations
  - The theory of (abstract) case, or linking theory.
  - Monostratal versus stratificational accounts.

Typological theories of case

- The typological distinction between *morphological categories* and *morphological strategies*:
  - A category can be realized by different strategies, within and across languages; (Croft, 1990).
  - Government & Binding's theory of abstract case, cf. (Haegeman, 1991).
- The role of morphological strategies and categories in our linking theory is as follows:

  Functional relation ↔ *Morph. category* ↔ **Morph. strategy**

- Morphological categories ("abstract cases") act as an interface between the language-universal roles and their language-dependent realization.

Morphological categories and strategies

- Examples of morphological strategies (Croft, 1990; Kruijff, 2001b).
- **Case**: The use of bound morphemes or *case markers* indicates the morphological category.

  (9) Czech *knih*-**u**, German *Kind*-**es**

- **Adposition**: A *function word* affixed to the wordform signals the morphological category.

  (10) Dutch **aan** *Kathy*

- **Positioning**: The wordform's position in the clause (usually, relative to the finite verb), indicates the morphological category.

  (11) English, Direct complement position for Accusative.

- **Linker**: Invariant marker that relates the modifer and the modified.

  (12) English **of** *Kathy, Kathy*'**s**

Kuryłowicz's theory of case

- To relate functional relations and their realization, Kuryłowicz (1964) proposes to distinguish *primary* from *secondary functions* of morphological categories:
  - The primary function of a morphological category is the functional relation it realizes using an unmarked morphological strategy.
  - The secondary function of a morphological category is the functional relation it realizes using a more unmarked morphological strategy.
- Consider the abstract Accusative:

				Czech	**German**
Patient	$\overset{primary}{\longleftarrow}$	*abstract Accusative*	$\overset{unmarked}{\longrightarrow}$	Acc. case	Acc. case
Dir:WhereTo	$\overset{secondary}{\longleftarrow}$		$\overset{marked}{\longrightarrow}$	*na*+Acc	*auf*+Acc

- As (Sgall et al., 1996)(p.72) note, the same is observable for Sanskrit.

Cross-linguistic generalization

- **Universality**: Morphological strategies are language-specific, and can be ordered by markedness. Morphological categories are assumed to be *universals* (universal interfaces), as are functional relations.
- Hence, we can make predictions about how valency frames will be realized in a particular language, given that language's inventory of morphological strategies (Skalička and Sgall, 1994; Kruijff, 2001b). Constituency cannot do this!
- This perspective has a long tradition in the Prague School of Linguistics, building on work by Jakobson, Mathesius, Skalička, Trnka, later influencing Daneš, Dokulil, Kuryłowicz, and Sgall and his collaborators.

- The point about functions was concisely made by Mathesius:

> "If we are to apply analytical comparison with profit, the only way of approach to different languages as strictly comparable systems is the functional point of view, since general needs of expression and communication, common to all mankind, are the only common denominators to which means of expression and communication, varying from language to language, can be reasonably brought."
> (Mathesius, 1936)(p.95/306)

Monostratal versus stratificational accounts

- Monostratal accounts
  - ϕ-mapping rules in LFG.
  - Structural rules for functional interpretation (Kruijff, 2001b).
  - TDG's linking constraints (Korthals and Debusmann, 2002).
  - Linking theory in HPSG (Wechsler, 1995; Davis, 1996).
  - Structure sharing and lexical compilation (Baldridge and Kruijff, 2002).
- Stratificational accounts:
  - Transduction or transformation: FGD, GB, ...

In conclusion

- Subcategorization and valency are two non-isomorphic argument structures that describe structure at different levels in a grammar.
- In a 'pure' dependency grammar, subcategorization frames need to be specified for two different structures – dependency and linear precedence. If we combine constituency and dependency, we need only a single subcategorization frame. Both perspectives arguably have their pros and cons, and both perspectives have been explored in the literature.
- Describing *just* valency leaves open the question of word order. If we want to combine valency and subcategorization, we need an account that explains how relations at the level of linguistic meaning are linked to relations at the level of surface structure.

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