

Formal & Computational Aspects of
Dependency Grammar

– Historical development of DG –

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 **Goal**

- **Goal:** To provide an overview of the historical development of dependency grammar, set within the context of theoretical linguistics.
- *History teaches something* ... or at least it might.

Reasons for looking at history

1. Dependency grammar as a **perspective** has developed out of the *interaction* of two views on dependency, namely *semantic dependency* and *syntactic dependency*.
2. The development of dependency grammar as a **theory** is closely related to the development of (formal) grammar as such.
 - In Ancient times and the Middle Ages, formal grammar was primarily dependency-based.
 - In contemporary formal grammar, the development of dependency grammars has usually been driven by the same issues as those addressed in formal grammar at large.
 - History can explain why people lost interest in dependency grammar, and why there is a renewed interest now.

1. DG in Ancient and Medieval times (± 350 BC – ± 1500 AD)
2. The formalisation of syntax (1950's, 1960's)
3. Meaning enters the stage (1970's)
4. The trouble with word order (1970's, 1980's)
5. Formal grammar meets logic (1990's)

Contents

Goal	2
Reasons for looking at history	3
Overview – History in overview	4
DG in Ancient and Medieval times	6
Dependency in Antiquity	7
Boethius' <i>determinatio</i>	12
Linguistics in Medieval Europe	13
The Arabic Linguistic Tradition	16
A history of modern formal grammar	18
The formalisation of syntax	19
Chomsky's <i>Syntactic Structures</i>	20
Chomsky's generative grammar	21
Tesnière	22
The generative strength of DG	24
Early non-transformational approaches	25
Meaning enters the stage	26
Logical form, dependency, and stratificational grammar	28
Montague and the development of formal semantics	30
The trouble with word order	31
Heads enter the scene	32

Grammar meets logic and computation	37
Grammar as a mathematical-logical system	38
In retrospect	41



DG in Ancient and Medieval times

- Development:
 1. The development of notions of semantic and syntactic dependency in Antiquity ([Percival, 1990](#)).
 2. The Arabic Linguistic Tradition.
 3. Boethius, and the notion of dependency in European Medieval linguistics.
- Notions of *semantic dependency* and *syntactic dependency* arose from the work of Ancient logicians and grammarians, later picked up by e.g. Boethius and then making their way into Medieval linguistics.
- In the Middle Ages, the close interaction with the Islamic world through Moorish culture in Southern Europe on the one hand, and the use of Hebrew by Jews all over Europe on the other hand, resulted in Medieval grammarians becoming interested in, and acquainted with, the Arabic Linguistic Tradition.
- In the Arabic tradition, syntactic dependency (inflection/head) had long been at the heart of the accounts of Arabic grammar.

Dependency in Antiquity

- Perhaps the earliest: Pāṇini's formal grammar of Sanskrit (written 350/250 BC).
- Relations of *semantic* dependency were implicitly recognized in the development of grammars in Antiquity.
- The definitions of word classes (parts of speech) illustrate this.
- Two different perspectives on word classes were developed:
 1. One perspective arose in the work of Ancient logicians such as Plato and Aristotle, who wanted to analyse propositions.
 2. Another perspective arose in the work of Ancient grammarians like Thrax or Apollonius, whose goal it was to interpret literary texts.

Dependency in Antiquity – the logicians

- Logicians looked at how propositions could be analyzed into their constituent parts.
 - Two main word classes were distinguished, namely nouns and verbs.
 - Nouns provide the subject, and the verb the predicate for a proposition.
 - The basic assumption underlying this perspective was that these two word classes, when put together, constitute a *minimal proposition*.
 - Later on, two further word classes would be added: Syncategorematic words (*all, every, no, some...*) and connectives (*and, if, ...*).
- “Dependency” or “priority”:
 - Without a verb, we don’t have a proposition (Aristotle, *On Interpretation*).
 - But without a noun (subject), we have nothing to anchor the process to.

Dependency in Antiquity – the grammarians

- Grammarians set themselves to interpreting literary texts, and hence did not adopt the kind of analysis that the logicians were using.
- Besides nouns and verbs the grammarians also distinguished the participle, article, pronoun, preposition, adverb and conjunction as word classes.
- Because the grammarians inherited nouns and verbs as word classes from the logicians, the two systems were not unrelated.
- For example, the adverb was conceived of as “a part of speech that complements or diminishes the meaning of the verb that it accompanies.” (Percival, 1990)(p.31)

Dependency in Antiquity – the grammarians

- The way an adverb was conceived of illustrates two implications:
 1. *Semantic specification*: The function of some words is to clarify or circumscribe the meanings of other words.
 2. *Asymmetrical relations*: An adverb needs a verb to modify, but a verb does not necessarily need an adverb to be modified by.
- These two ideas were elaborated in the work of Apollonius (200 AD).
- Priscian (500 AD) based his Latin grammar on Apollonius' ideas, and from there these notions made it into European Medieval grammar through Boethius' interpretation of Priscian.

Dependency in Antiquity – the grammarians

- With Apollonius and Priscian, we see the Ancient conception of dependency being “rounded off”.
- There are two major word classes (noun, verb), and six minor word classes.
- Nouns and verbs are major because ancient grammarians conceived of a sentence as a group of words expressing a complete thought (just like the logicians!).
- The minor word classes had supportive functions in relation to the major classes.
- Nouns and verbs were not equally major: The noun expresses the subject, the verb the predicate. Although a verb without a subject has no *raison d’être*, the verb was considered prior to nouns.

Boethius' *determinatio*

- The first person who introduced a special term to refer to the supportive function of the minor word classes was the logician Boethius (ca. 480-524/6 AD).
- In his commentary on Aristotle's *On Interpretation*, Boethius referred to quantifiers (syncategorematic words) as *determinationes*, "specifiers".
- In his *De divisione*, Boethius develops the notions of specification further to include not only quantifiers, but also words from other word classes.
 - In isolation, words are *vague* and need to be specified further.
 - For example, *Da mihi!* ("Give me!") is vague if it is not clear what should be given.
- Boethius' *determinatio* thus cuts across word classes, adding an idea of *semantic specification* or *semantic role* to the major word classes noun and verb.

Linguistics in Medieval Europe

- Boethius' writings were widely disseminated in Latin-speaking Europe, because they were part of the *logica vetus*, the "Old logic".
- Given the dominant position of logic in Medieval education, grammarians quickly adopted Boethius' *determinatio*.
- Next to the semantically oriented use of determination, grammarians introduced the (syntactic) notion of 'government'.
- Although grammarians in Antiquity were aware of the idea (notably, see the Stoics), Medieval grammarians (12C AD) were the first to introduce technical terms to refer to the different kinds of government relations.
- The general term for government was Latin *regimen*: A verb governs all the major nominal expressions in a sentence, determining e.g. nominal inflection (similar to the notion of head in the Arabic linguistic tradition.)
- Other government relations were *exigentia* (requirement) between adverbs and verbs, and *deservire* (or *servire*) between prepositions and nouns.

Linguistics in Medieval Europe

- In the 13th century AD, Latin scholars introduced the term *dependentia*.
- This term was closely related to Boethius' *determinatio*: If A determines B, then B is dependent on A.
- Relation between syntactic and semantic dependency: "If A governs B, then B determines A, and hence A is dependent on B, with 'B terminating the dependency.' " (Percival, 1990)(p.35).
- In medieval Europe, dependency-based notions were used by speculative and modistic grammarians, particularly Thomas of Erfurt or Martin of Dacia.

Linguistics in Modernity

- After the Middle Ages, the idea of semantic specification (*determinatio*) remained, even in the new humanistic educational system (15C AD and on), whereas *dependentia* occurs less often in the Modern period.
- Later, in the 17th and 18th century, grammarians added several important concepts to the notion of dependency:
 1. The notion of *dependent clause* (Port Royal logicians, middle 17th century).
 2. The notions of *modifiers* and *modification* (contributed to the French grammarian Claude Buffier, early 18th century).
 3. The notion of *complement* (Girard in 1747, further developed by Du Marsais and Beauzée).
- This then leads up to the developments in the 20th century ...

The Arabic Linguistic Tradition

- We also find notions of syntactic and semantic dependency in the Arabic Linguistic Tradition.
- European linguists came in contact with Arabic grammar through direct contact with the Islamic world in Moorish Southern Europe, and through Hebrew.
- They became interested in Arabic grammar because Arabic was a type of language different from Latin, and had resulted in a different kind of grammar.
 - (Percival, 1993): The Medieval *genus/species* discussion concerning grammar – Is there a universal grammar?
- Although the idea of systematic treatment of Arabic grammar arose from Hellenistic thinking, the Arabic Linguistic Tradition developed independently from European linguistics.

The Arabic Linguistic Tradition

- The first known *theory* (systematic treatment) of Arabic grammar, including various levels of linguistic information, was based on concepts that now form the core of dependency grammar: *Kitāb al-Uṣūl* of Ibn al-Sarrāġ (d.928).
- The *Kitāb al-Uṣūl* codifies the Arabic tradition epitomized in Sibawayhi's (d.798) *Kitāb* and al-Xalīl's (d.791) *Kitāb al-'Ayn* (lexicography: first Arab dictionary)
- The *uṣūl* ('foundations'), covering all linguistic facts, and the *'ilal* ('causes')
- Syntax (*nāḥw*) distinguishes a head (*āmil*) and its dependents (*ma'mūl fī-hi*). Nominal dependents can have different roles, such as *fā'il* ('actor,subject'), *mafā'il* ('object'), *mubtada'* ('topic') or *khābar* ('comment').

References: (Owens, 1988; Bohas et al., 1990).



A history of modern formal grammar

- We are looking at the developments starting in the 1950's, dividing (sometimes parallel) historical developments into four phases:
 1. Formalisation: Away from descriptive linguistics and behavioralism
 2. Including meaning: Compositionality
 3. Word order: Needing stronger formalisms
 4. Grammar meets logic & computation: Grammar as a mathematical system.
- In these phases, theoretical linguists addressed similar issues, but worked them out differently depending on the perspective they took – constituency-based, or dependency-based.
- These historical developments help explain why people lost their interest in DG, and why their interest is now renewed – without needing a (biased) comparison between constituency & dependency perspectives.



The formalisation of syntax

- What preceded:
 - The 1930's: Bloomfield's (descriptive) notion of constituency, behaviorism in linguistics
 - The 1930's-1940's: Groundbreaking work in mathematical logic, theory of computers and computation (Gödel, Church, Kleene, Turing, Post)
- Chomsky's impact on the enterprise of syntax:
 - Mathematical results establishing formal language theory and the scale of types of grammar (nowadays called the Chomsky Hierarchy)
 - Critical review of B.F. Skinner's (1957) book *Verbal Behavior*
 - Chomsky's (1957) *Syntactic Structures*

References: (Chomsky, 1957; Davis, 1965; Sag and Wasow, 1999).

Chomsky's *Syntactic Structures*

- The preface of *Syntactic Structures* emphasizes the heuristic role of formalization in clarifying linguistic analyses, supporting empirical testing and falsification:

“... The search for rigorous formulation in linguistics has a much more serious motivation than mere concern for logical niceties or the desire to purify well-established methods of linguistic analysis. Precisely constructed models for linguistic structure can play an important role, both negative and positive, in the process of discovery itself. By pushing a precise but inadequate formulation to an unacceptable conclusion, we can often expose the exact source of this inadequacy and, consequently, gain a deeper understanding of the linguistic data. More positively, a formalized theory may automatically provide solutions for many problems other than those for which it was explicitly designed. Obscure and intuition-bound notions can neither lead to absurd conclusions nor provide new and correct ones, and hence they fail to be useful in two important respects.”

Chomsky's generative grammar

- **Generative grammar:** A context-free component, generating “kernel sentences”, and a transformation component (cf. Harris (1957))
 - (A) Generate a (finite) set of elementary sentences, and use transformations to broaden it to the class of representations of all sentences for a language.
 - (B) Generate a (finite) set of representations of all sentences of a language, and then use transformations to arrive at surface forms.
- Variant (B) led to *stratificational grammar*,
 - Stratificational grammar, cf. e.g. (Hays, 1964; Lamb, 1966).
 - Chomsky's (1965) *Aspects of the Theory of Syntax* adopts (B), and would later develop into Government & Binding theory (Chomsky, 1981), cf. (Haegeman, 1991; Higginbotham, 1997)

Tesnière

- The modern notion of dependency grammar is usually attributed to Tesnière (1959) (dating back to 1939)
- Tesnière aimed at a notion of grammar that would be useful in teaching foreign languages.
- Tesnière's theory has two parts: The dependency theory, and the translation theory.
- In the dependency theory, Tesnière distinguished between *l'ordre structurel* and *l'ordre linéaire* – what we nowadays would understand as immediate dominance and linear precedence.
- Tesnière's grammar was a *structuralist* grammar, imposing a one-to-one relation between meaning and structure.

Early stratificational DGs

- Employing Tesnière's ideas about dependency, various formalisations in the form of stratificational DGs were proposed.
- Functional Generative Description:
 - Early formalization by Sgall *et al.* in (1969), later developed by Petkevič into a purely dependency-based system in (1987; 1995).
 - Praguian functionalism (Mathesius) meets dependency-based structuralism (Tesnière): Sgall *et al.* (1986), and Panevová (1974; 1975).
 - Focuses on *linguistic meaning* and its realization.
- Meaning-Text Theory:
 - Gladkij & Mel'čuk (1975), Mel'čuk (1988)
 - Similarly to FGD, MTT focuses on the relation between meaning and its realization as 'text' (=utterance).
- Abhängigkeitgrammatik: Kunze (1975)

The generative strength of DG

- Chomsky’s formal language theory made it possible to ask for the *generative strength* of a grammar.
- For dependency grammar, various authors established such results:
 - Gross (1964), Hays (1964), Gaifman (1965), Robinson (1970).
 - Most authors established that a *class* of DGs are weakly equivalent to context-free PSGs.
 - But, Gross (1964)(p.49) claimed that “The dependency *languages* are exactly the context-free languages.” Similar (mistaken) claims were made frequently in the literature.
 - Unfortunately so! Early on, CFGs were shown to be inadequate to model natural language, though; cf. Postal (1964), Peters & Ritchie (1971), also Ross (1967; 1970).
- This might have been one of the reasons why people lost interest in dependency grammar that time.

Early non-transformational approaches

- The landscape of formal grammar was not covered solely by generative (transformational) approaches.
- Bar-Hillel focused primarily on categorial grammar ([Bar-Hillel, 1953](#)), elaborating Ajdukiewicz's ([1935](#)) syntactic calculus.
 - With his algebraic linguistics ([Bar-Hillel, 1964](#)), Bar-Hillel aimed at providing a notion that was to cover a broader range of approaches to formal description of grammar (including dependency grammar).
- Lambek ([1958](#); [1961](#)) similarly focused on categorial grammar, though of a more logical (proof-theoretical) kind than Bar-Hillel's.
- Bar-Hillel, Gaifman and Shamir showed in 1964 that, like DG, Bar-Hillel's categorial grammar was context-free; cf. ([Bar-Hillel, 1964](#)).
- Chomsky ([1963](#)) conjectured that Lambek's grammars were also context-free; cf. ([Pentus, 1997](#)) for the proof of that conjecture, and ([Buszkowski, 1997](#)).

Meaning enters the stage

- Chomsky was, in general, sceptical of efforts to formalize semantics. *Interpretative semantics* or the autonomy of syntax: Syntax can be studied without reference to semantics (cf. also Jackendoff).
- Criticism on both transformational and non-transformational approaches:
 - Transformations do not correspond to syntactic relations, relying too much on linear order.
 - Similarly, Curry (1961; 1963) criticized Lambek for the focus on order (directionality). Instead, Curry proposed a system of *functors* (i.e. valency, alike (Peirce, 1898)), including a type hierarchy, and considers functors to be “what Harris and Chomsky call transformations.” (1961) This leads to *tectogrammatical* structures, which Curry distinguishes from *phenogrammatical* structures.

Meaning enters the stage

- Different ongoing efforts:
 - Developing a notion of (meaningful) logical form, to which a syntactic structure could be mapped using transformations. Efforts either stayed close to a constituency-based notion of structure, like in *generative semantics* (Fodor, Katz), or were dependency-based (Sgall *et al*, particularly Panevová (1974; 1975); Fillmore (1968)). Cf. also work by Starosta, Bach, Karttunen.
 - Perlmutter, Postal and relational grammar: “Syntactic relations are primitive, and indispensable notions.”
 - Montague’s formalization of semantics – though Montague and the semanticists in linguistics were unaware of one another, cf. (Partee, 1997)

Logical form, dependency, and stratificational grammar

- Formulation of a notion of *logical form*, describing the linguistically expressed/expressible meaning, in terms of dependency relations.
- Panevová, Sgall focused on meaningful dependency relations like Actor, Patient, that could be differentiated on the basis of behavior in surface syntax (Panevová, 1974; Panevová, 1975).
- This set the Praguian approach apart from Fillmore (1968), who defined a set of dependency relations (*cases*) without providing overt (syntactic) criteria for distinguishing them.
- Following Curry (1961; 1963), Sgall *et al* would later talk of functors, and tectogrammatical representations. Unlike the logical form in generative semantics, a (Praguian) tectogrammatical representation does need further interpretation; cf. (Sgall et al., 1986), also (Partee, 1997).

Logical form, dependency, and stratificational grammar

- In a stratificational setting, a logical form (“deep structure”) is transformed in successive stages into a representation of surface form.
- This makes it important for there being a mapping between dependency relations or *function* and form! This holds for stratificational theories like MTT, FGD, GB, but is also addressed in non-transformational approaches like LFG.
- The debate concerning the relation between function and form also carries over to semantics, particularly theories based on θ -frames.
- In a later lecture (on valency) we shall return to these issues.

Montague and the development of formal semantics

- The foundational work by Frege, Carnap, and Tarski had led to a rise in work on modal logic, tense logic, and the analysis of philosophically interesting issues in natural language. Philosophers like Kripke and Hintikka added model theory.
- These developments went hand-in-hand with the “logical syntax” tradition (Peirce, Morris, Carnap), distinguishing syntax (well-formedness), from semantics (interpretation), and pragmatics (use).
- Though the division was inspired by language, few linguists attempted to apply the logician’s tools in linguistics as such. This changed with Montague.
- “I reject the contention that an important theoretical difference exists between formal and natural languages.” (Montague, 1974)(p.188)
- A *compositional* approach, using a “rule-by-rule” translation (Bach) of a syntactic structure into a first-order, intensional logic. This differed substantially from transformational approaches (generative or interpretative semantics).

References: (Partee, 1996; Partee, 1997; Gamut, 1991)



The trouble with word order

- Traditional phrase-structure grammar (Bloomfield) is context-free (CF-PSG), and therefore not strong enough to model natural language syntax.
- Chomsky (1957) therefore added transformations on top of a CFPSG.
- But, there are linguistic problems with transformations (no corresponding linguistic concept), and formal problems, Peters & Ritchie (1971; 1973).
- Moreover, Chomsky's arguments against CFPSG (incapable of generalization, mathematical proof concerning string languages) were shown to be flawed (e.g. by Gazdar, Pullum).
- Finally, studies in 'nonconfigurational' languages (e.g. Australian) starting in the 1970's gave rise to a more relational view on structure, in contrast to the configurationality of English.
- These problems led to the development of new, non-transformational grammar frameworks like Relational Grammar and Arc Pair Grammar, LFG, GPSG

Heads enter the scene

- Heads (asymmetric relations) start entering the scene, in various guises.
- Studies in nonconfigurational languages revealed that relations rather than phrases are typologically significant for the expression of meaning (cf. (Greenberg, 1966), (Bresnan, 2001)); Relational Grammar, Arc Pair Grammar, LFG.
- Distinction between rules for *Linear Precedence* (LP) and *Immediate Dominance* (ID).
 - Similar distinction proposed earlier (Curry, 1961; Šaumjan and Soboleva, 1963) but criticized in (Chomsky, 1965). In transformational grammar, several authors in the 1960's and 70's had considered *unordered* trees.
 - Transformations are too strong (Peters and Ritchie, 1973) if unconstrained. The best way to constrain a component of grammar is to eliminate it (Gazdar): Back to CFPSG, but a *generalized* form thereof using ID/LP and metarules – GPSG (Gazdar et al., 1985).
- (Uszkoreit, 1987) generalizes GPSG, defining more powerful LP rules.

Heads enter the scene: Categorical Grammar

- Related work was going on in categorial grammar (functional rather phrasal structure): (Venneman, 1977) binding dependency and functional structure – again, combining vertical and horizontal organization.
- In general though, categorial grammar tried to deal with flexible word order by introducing means of composition that were more powerful than application:
 - Bach’s wrap operations (1984).
 - Ades and Steedman’s combinatorial rules (1982). also Jacobson, Szabolcsi, and later Hoffman (1995), Baldrige (1998), Steedman (1996; 2000).
 - Moortgat’s generalized connectives (1988), also work by Oehrle, Morrill, Van Benthem.
 - Only towards the end of the 1980’s, early 1990’s is dependency again explicitly introduced into categorial grammar: (Steedman, 1985; Hepple, 1990; Pickering, 1991; Moortgat and Morrill, 1991; Barry and Pickering, 1992; Moortgat and Oehrle, 1994).

Heads enter the scene: HPSG

- The developments in GPSG, LFG, and Arc Pair Grammar showed the feasibility of a nontransformational perspective, employing a relational perspective to obtain better generalizations.
- Furthermore, in computer science the 1980's witnessed the development of *feature logics*.
 - Kasper, Rounds, Johnson, Moshier – cf. (Rounds, 1997).
 - Feature logics were rapidly embraced and introduced into formal grammar by e.g. Carpenter (1992), King (1989), Pereira & Shieber (1987).
- Pollard & Sag (1987; 1993) built HPSG on these developments.

Heads enter the scene: HPSG

- Levels are related using *structure sharing* (Johnson and Postal, 1980) through token identity, rather than by having transformations.

(Token Identity leads to parallel rather than serial structure building, comparable to LFG and (later) categorial grammar.)

- A *multilevel* yet *monostratal* sign-based approach, cf. (Ladusaw, 1988).
- HPSG replaced GPSG's metarules by a lexical account, reinterpreting metarules as lexical rules (*lexicalization*).
- Later word order accounts in HPSG: (Reape, 1994; Kathol, 1995; Penn, 1999).

Tree-Adjoining Grammar and syntactic dependency

- Joshi *et al*'s Tree-Adjoining Grammar (TAG), starting back in 1975: The natural languages are somewhere inbetween CFLs and CSs.
- TAG is a limited extension of CFGs to “mildly context-sensitive” grammars ($CFG \subset TAL \subset IL \subset CSL$).
- TAGs define *initial trees* and *auxiliary trees* to which we can apply the operations *substitution* and *adjunction* to combine trees.
- Various incarnations of TAG have been used to model syntactic dependency: Rambow and Becker's D-Tree grammar, Kahane et al's TAG-based formalization of Mel'čuk's Meaning-Text Theory.



Grammar meets logic and computation

- We can distinguish various reasons for marrying grammar to logic and computation.
- Specifying a grammar as a logic makes the grammar into a *mathematical-logical system* that we can investigate for specific *properties* such as soundness, completeness, decidability.
- We can also use logic to equip a grammar with a means to *interpret* the representations it yields for the meaning that an expression realizes.

Grammar as a mathematical-logical system

- We can use logics to specify a grammar framework as a mathematical-logical system.
- We can then investigate these systems on particular (desirable) properties.
- (Note that some frameworks, like TAG, are *inherently* already mathematical systems, albeit not *logical* systems.)
- **Feature logics:** HPSG, cf. (King, 1989; Pollard and Sag, 1993; Richter et al., 1999)
- **Resource-sensitive type logics:** categorial grammar, cf. (Morrill, 1994; Kurtonina, 1995; Moortgat, 1997)
- One “but” to this enterprise: a grammar framework is a tool for a linguist, and hence the mathematics should be in service of linguistics – we shouldn’t force a linguist to become a mathematician!

Logical interpretation of linguistic meaning

- What distinguishes a logic from a formal representation is that a logic is a formal representation that comes with a *model* interpretation that representation.
- **Montague semantics**: Used in early LFG, GPSG, Montague Grammar, Type-Logical Grammar, TAG (Synchronous LTAG).
- **Transparent Intensional Logic** (Tichý, 1988; Materna, 1998): Used for dependency grammar (FGD), (Materna and Sgall, 1980; Materna et al., 1987; Svoboda and Materna, 1987; Vlk, 1988).
- **Modal logic**: Used in dependency grammar frameworks, e.g. (Bröker, 1997; Kruijff, 2001).
- **Linear logic**: Used in contemporary LFG, (Crouch and van Genabith, 1998).

Grammars as computational systems

- Even though a *parser* is not the same as a *grammar*, many grammars nowadays embody a means of *computation*.
- **Unification (constraint-based reasoning)**: LFG, HPSG, categorial grammar (UCG, CUG), dependency grammar (UDG, DUG, TDG)
- **“Parsing as deduction”**: in extremis, categorial grammar
- **Optimality theory**: Robust constraint-solving, e.g. LFG or dependency grammar ([Hajičová, 2000](#)).



- Dependency grammar has a long history, going back more than two millennia.
- The core concepts of dependency grammar *as a perspective*, namely the relational view arising from the head/dependent asymmetry, has proven useful (and even necessary) for cross-linguistic accounts of grammar (cf. also (Greenberg, 1966; Hawkins, 1983)), particularly in the explanation of word order and the relation between surface structure and meaning.
- Even though dependency grammar had initially lost its appeal by the early 1970's, its core concepts were eventually introduced again in various grammar frameworks to complement constituency.
- Moreover, now that stronger formalisms are available, also dependency grammar *as a framework* arises again.

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