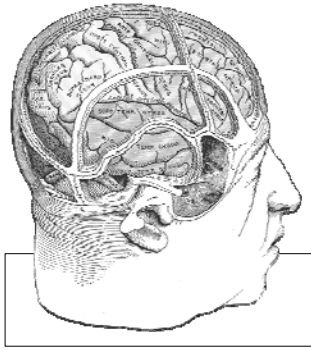
SYNTAX & THE BRAIN



A new perspective on the role of Broca's area in syntactic processing

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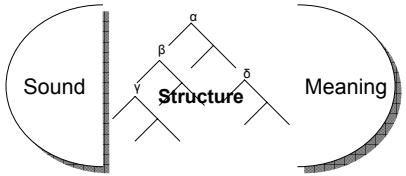
The language faculty

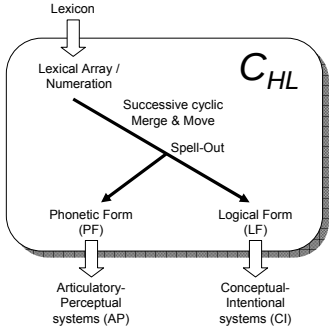
- *I will assume here an approach to the study of language that takes the object of interest to be an internal property of persons, a subcomponent of (mostly) the brain that is dedicated to language:[1] the human "Faculty of Language."* (Chomsky 2004:104)
  - [1] *As a system, that is; its elements might be recruited from, or used for, other functions.* (p. 124, note 1)

2

The computational system of human language, C_{HL}

- C_{HL} derives a set of linguistic representations, PF and LF, from a lexical array drawn from the lexicon (Chomsky 1995, 2001, 2004, 2005, to appear).
- Cf. the Saussurean sign





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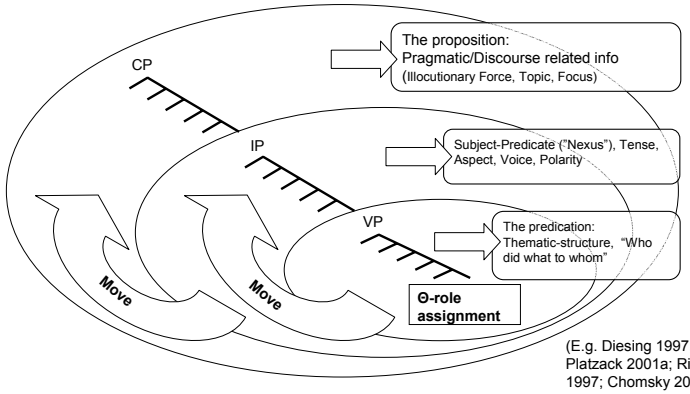
Structure-to-meaning mapping



(E.g. Diesing 1997; Platzack 2001a; Rizzi 1997; Chomsky 2001, to appear)

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Syntax & neurolinguistics

- The syntactic derivation is internally constrained by
  - Computational Economy
    - Locality, Economy of Derivation, Full Interpretation
  - Structure-dependency
    - Hierarchical structure, Constituency, Structure Preservation
- Movement can be (functionally) externally motivated by information structure (e.g. Saddy & Uriagereka 2004)
- Question for neurolinguistics: How are these computations implemented at different levels of biological abstraction? (Poeppel & Embick 2005)

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Modularity & implementation

- Modules may be found at all levels of description

Cognitive Modules:
(Chomsky 2000)

-**Face recognition**
-**Language**

Input systems:
(Fodor 1983)

-**Perception**

Cell Structure:

-**Neurons**

- There need not be any simple correspondence between modularity at one level and modularity at another level. (Chomsky 2004, Jenkins 2000, Friston et al. 1996)

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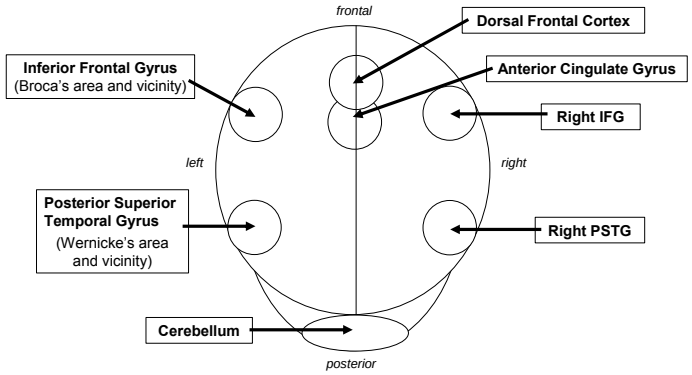
The syntax Network

- *Syntax* (C_{HL}) is implemented as a network distributed over several computational "centres"



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A 'disappearing' network

- 'Unconstrained' task subtractions show massive activation in the whole (widely distributed) network

Linguistic:		**Non-linguistic:**
("Anomalous or OK?") ***The doctor has not heard any noises.*** ***Which houses has your wife not eaten?***	>	("Watch countdown:") ***4…3…2…1…***

- In more constrained tasks, only parts of the network will light up: The network itself will become increasingly 'invisible' (cf. Dogil et al. 2002:87).

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Basic questions

- The vast majority of syntactic imaging studies have focused on movement that changes the order of θ-roles.
  - Does movement that does not affect the θ-order also increase activation in Broca's area?
    - Movement ➔ Broca's area?
  - Is *canonicity* really the crucial factor?
    - Non-canonical ➔ Broca's area?

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The experiment

- 2x2 factorial design
- All four conditions involve operators.
  - They all license NPIs such as *overhovedet* 'at all'.
  - In *yes/no* questions, OP is the silent operator in spec-CP.

Move / Target	With extra XP movement	Without extra XP Movement	Illocutionary force
Spec-NegP (IP-domain)	**A: NEG-shift** ingen NP *no*	**B: Neg Adv** *ikke* (…*nogen* NP) not any	Declarative
Spec-CP (CP-domain)	**C: *Wh-question*** Hvilken NP *which*	**D: *Yes/No* question** OP Verb Subj	Interrogative

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The experiment

- Task: *Well-formed* or *Anomalous*?
  - Sentences are presented visually
  - Interval = 4 seconds
  - All sentences contain 6 words to avoid 'length'-bias
  - OK:Anom ratio = 3:1 (25% anom.) to avoid chance bias (guessing)
  - Total: 240 sentences (180 well-formed and 60 anomalous)
- Subjects:
  - 11 right-handed, male, native speakers of Danish with no history of neurological damage
- Contrasts are kept as minimal as possible in order to isolate the movement effects.

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NEG-shift

- In Danish (and many other languages), negative clauses with an indefinite quantified object can be constructed in two ways (Christensen 2005):

(1) **Obj in situ: Canonical VO**
- Negation and quantification are realized on separate lexical items:

Hun har **ikke**$_{[Neg]}$ læst [**nogen**$_{[Quant]}$ bøger]
She has not read any books

(2) **NEG-shift: Non-canonical OV**
- Negation and quantification are realized on the same lexical item:

Hun har [**ingen**$_{[Neg, Quant]}$ bøger] læst t_{Obj}
She has no books read

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Input: +/- NEG-shift

- A. OK: **Konen har vist ingen sko haft.**
  Wife-the has I-guess no shoes had
- A. anom: **Konen har vist ingen ideer spist.**
  Wife-the has I-guess no ideas eaten
- B. OK: **Konen har ikke haft nogen sko.**
  Wife-the has not had any shoes
- B. anom: **Konen har ikke spist nogen ideer.**
  Wife-the has not eaten any ideas

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Input: +/- *Wh*-movement

- C. OK: **Hvilke sko har konen ikke haft?**
  Which shoes has wife-the not had
- C. anom: **Hvilke ideer har konen ikke spist?**
  Which ideas has wife-the not eaten
- D. OK: **Har konen ikke haft nogen sko?**
  Has wife-the not had any shoes
- D. anom: **Har konen ikke spist nogen ideer?**
  Has wife-the not eaten any ideas

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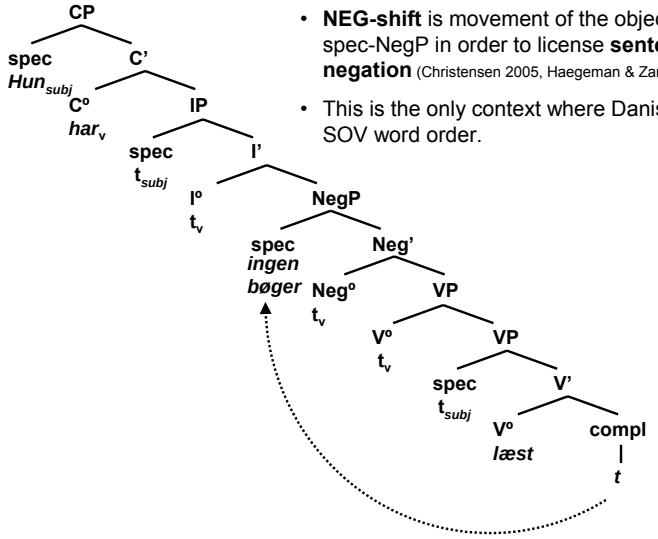

- **NEG-shift** is movement of the object to spec-NegP in order to license **sentential negation** (Christensen 2005, Haegeman & Zanuttini 1991).
- This is the only context where Danish has SOV word order.

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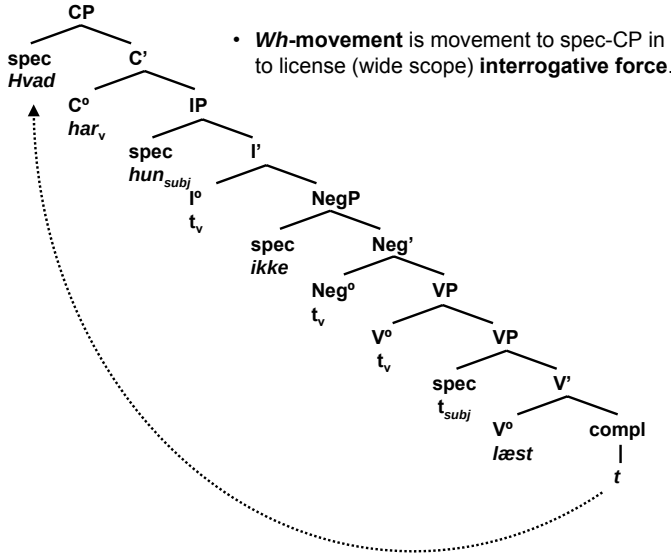

- ***Wh*-movement** is movement to spec-CP in order to license (wide scope) **interrogative force**.

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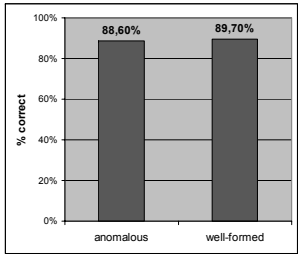
Behavioural results

- **Veridicality** (the possibility of having a truth value) has **no influence** on judgment
- Anomalous sentences are judged as such, regardless of the fact that many are always true, e.g.:

  The wife hasn't eaten any ideas



- Subjects systematically respond as predicted:
  - Difference is not significant (p=0,52)
  - Performance at ceiling even though no response also counts as an error

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- The are also no significant differences in **reaction time** (p>0.23) in any of the contrasts
  - No differences in task difficulty

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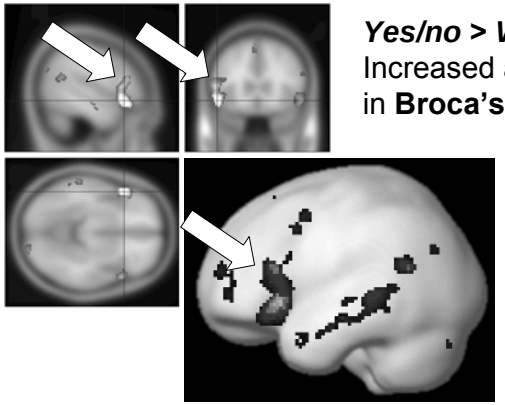
The CP-domain: *Wh*-Movement



Yes/no* > *Wh: Increased activation in **Broca's area**

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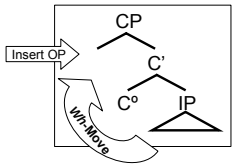
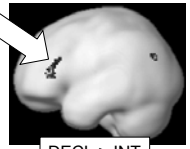
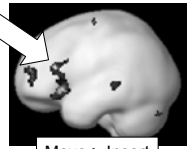
The CP-domain: *Wh*-Movement

- The activation seem to reflect differences in the amount of movement to CP (Christensen, to appear):
  - Declaratives: 100% Movement to spec-CP (Subj)
  - Interrogatives: 50% Movement (wh-Obj), 50% OP-insertion




DECL > INT


Move > Insert

- Friederici et al. (2006:7):
  - Activation in Broca's area is "modulated parametrically as a function of the number of permutation operations that need to be reconstructed".
  - "Permutation operations" = scrambling into CP above the subject.

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The CP-domain: corroborating results

- fMRI studies:
  - Object relatives (Ben-Shachar et al. 2003, Just et al. 1996)
  - *Wh*-movement (Ben-Shachar et al. 2004)
  - Topicalization (Ben-Shachar et al. 2004, Dogil et al. 2002)
  - "Long" Scrambling (= above the subject)

  (Bornkessel et al. 2005, Fiebach et al. 2005, Grewe et al. 2005, Röder et al. 2002)

- Lesion studies:
  - The CP-domain is particularly affected in Broca's aphasia (Cf. e.g. Burchert et al. 2005, Friedmann 2003, Grodzinsky 2000, Platzack 2001b, Van der Meulen 2004)

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The IP-domain: NEG-shift

***Ingen 'no' > Ikke nogen 'not any'*:**
No increased activation

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The IP-domain: corroborating results

- Other fMRI studies:
  - "Short" scrambling (below the subject) does not increase activation in Broca's area either
    (Fiebach et al. 2005, Grewe et al. 2005, Röder et al. 2002)
- Lesion studies:
  - Negation is rarely affected in Broca's aphasia
    (Hagiwara 1995, Lonzi & Luzzatti 1993, but see Bastiaanse et al. 2002)

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The VP-domain

- fMRI studies:
  - Semantic > Non-semantic / pseudo words
    - (right IFG BA44/45, Röder et al. 2002)
  - Dative alternation
    - (*Give* *someone* *something* vs. *give* *something* *to* *someone*)
    - (left ventral prefrontal gyrus BA6/9 and insula BA13, Ben-Shachar et al. 2004)
- Lesion studies:
  - Right-brain damage leads to problems with thematic structure (incl. dative alternation), narratives, irony, jokes (Schneiderman & Saddy 1988)

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The Domain Hypothesis

- The computational system interfaces with other cognitive systems during the derivation.
- Interface conditions may motivate syntactic movement.
- Syntactic movement increases neural activation.
- Activation patterns reflect structure-to-meaning mapping.
  - i.e. movement operations motivated by different types of information.

- **The crucial factor is**
  - **neither *movement* nor *non-canonicity* per se,**
  - **but rather the *target domain***

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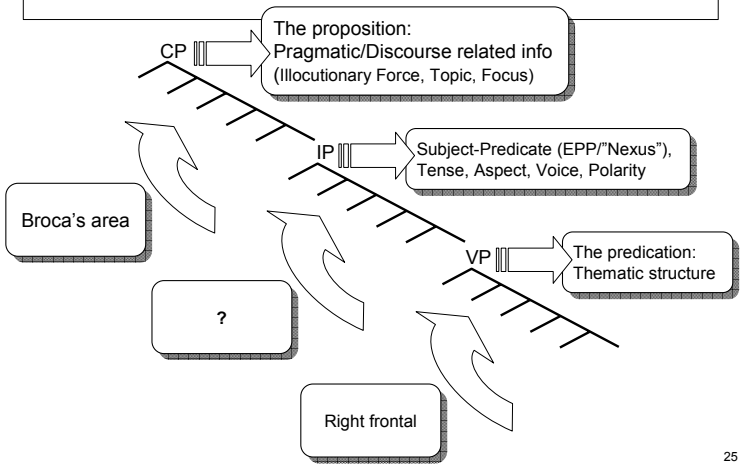
The Domain Hypothesis



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