

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:

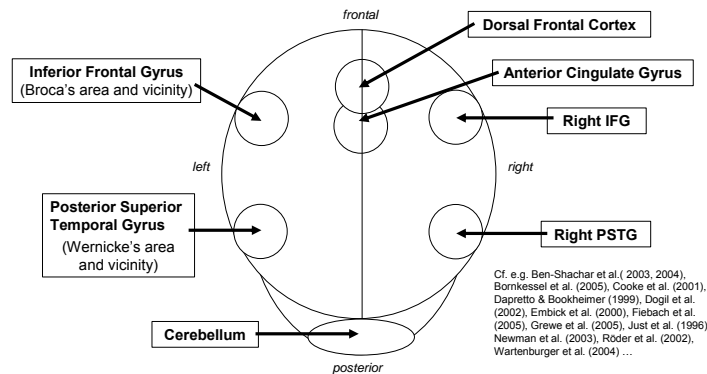
-Neurons

- 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

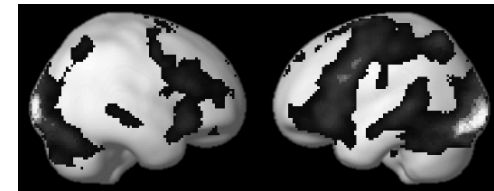
- *Syntax* (C_{HL}) is implemented as a network distributed over several computational "centres"



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A 'disappearing' network

- 'Unconstrained' task subtractions show massive activation in the whole (widely distributed) network
 - Language (semantic judgment) > (looking at) numbers



- 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 \rightarrow Broca's area?
 - Is *canonicity* really the crucial factor?
 - Non-canonical \rightarrow 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 <i>no</i>	B: Neg Adv <i>ikke (...nogen NP)</i> not any	Declarative
Spec-CP (CP-domain)	C: Wh-question Hvilken NP <i>which</i>	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, and 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

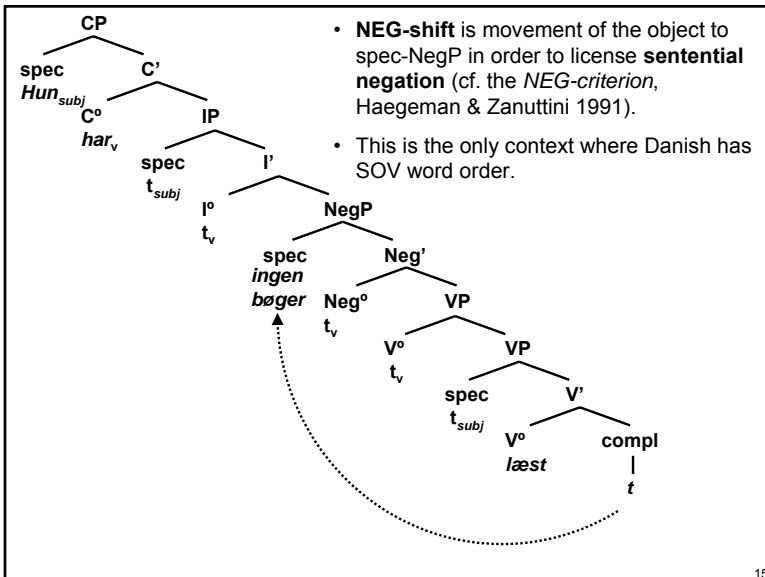
- A. OK: **Konen har vist ingen sko haft**
Wife-the has I-guess no shoes had
- A. anom: **Konen har vist ingen ideer spist.**
Wife-the has I-guess no ideas eaten
- B. OK: **Konen har ikke haft nogen sko.**
Wife-the has not had any shoes
- B. anom: **Konen har ikke spist nogen ideer.**
Wife-the has not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

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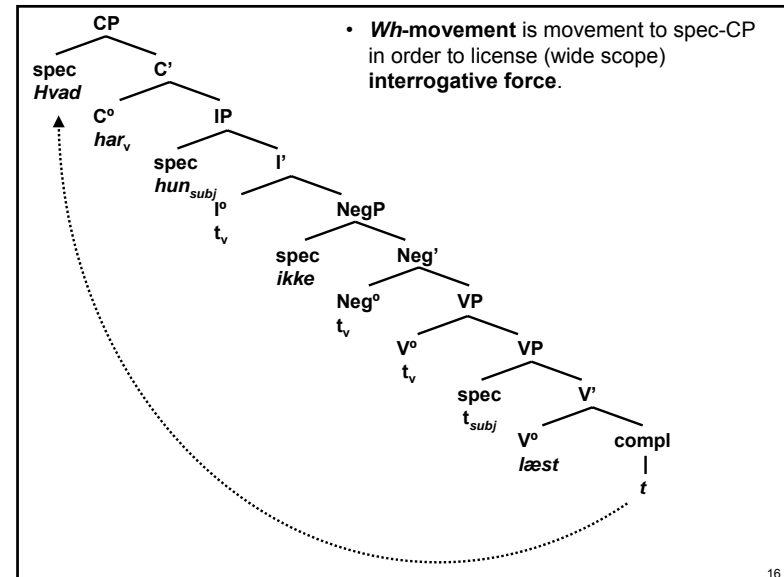
Input: +/- Wh-movement

- 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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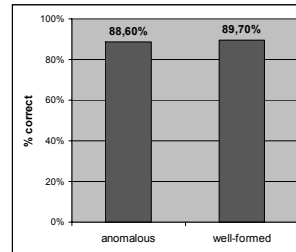
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Behavioural results

- **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.:

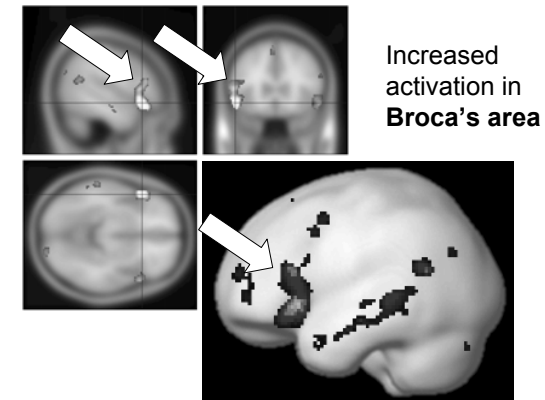
The wife hasn't eaten any ideas



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



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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 (Fiebach et al. 2005, Grewe et al. 2005, Röder et al. 2002)*
- Lesion studies:
 - The CP-domain is particularly affected in Broca's aphasia (Friedmann 2003, Grodzinsky 2000, Platzack 2001b, Van der meulen 2004, and many others...)

*Reanalysis of stimulus data

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The IP-domain: NEG-shift

No increased activation relative to non-movement...

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The IP-domain: corroborating results

- Other fMRI studies:
 - “Short” scrambling 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, Bastiaanse et al. 2002)

*Reanalysis of stimulus data

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The VP-domain

- fMRI studies:
 - Semantic > Non-semantic / pseudo words
 - (right IFG BA44/45, Röder et al. 2002)
 - Dative alternation
 - (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 derivation
- Syntactic movement increases neural activation
- Activation patterns reflect interfacing (and thus different types of information)
 - Movement to CP increases activation Broca’s area
 - Movement to IP, so far, shows no effect
 - VP-internal operations increase activation in the right frontal system
- In short: the **target domain** is important

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Agrammatism: van der Meulen (2004)

- French Broca patients:
 - Comprehension of Obj questions with *wh*-in-situ is significantly better than comprehension of both Subj and Obj *wh*-questions with movement.

[_{CP} C° [_{IP} Le garçon arrose qui]]? (Obj in situ)
 Q the boy splashes who (less impaired)
 “Who does the boy splash (with water)?”

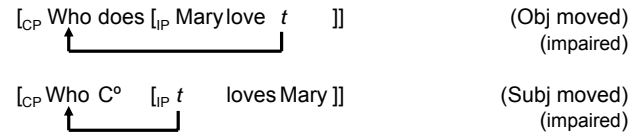
[_{CP} Qui [_{C°} (est-ce que) [_{IP} le garçon arrose t]]]? (Obj moved)
 Who Q the boy splashes (more impaired)

[_{CP} Qui [_{C°} (est-ce que) [_{IP} t arrose le garçon]]]? (Subj moved)
 Who Q splashes the boy (more impaired)
 “Who splashes the boy (with water)?”

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Agrammatism: van der Meulen (2004)

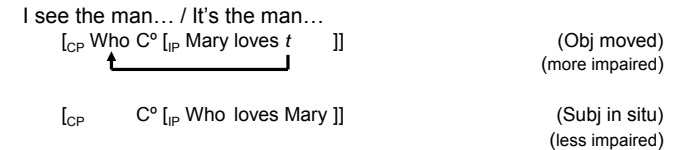
- *Wh*-questions deviate from the standard Subj-Obj asymmetry in agrammatism:
 - No significant difference between Obj and Subj *wh*-questions;
 - In both, performance is significantly impaired but above chance.
 - Hence, there is movement to spec-CP in both:



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Agrammatism: van der Meulen (2004)

- In (English and French) clefts and relatives the classic asymmetric pattern is observed:
 - Obj relatives are more impaired than Subj relatives.
- Van der Meulen's (2004) suggestion:
 - only Obj relatives and Obj clefts involve XP-movement;
 - in Subj relatives and Subj clefts, the subject remains in the canonical subject position, spec-IP.



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Agrammatism: van der Meulen (2004)

- "Broca patients have less difficulty comprehending constructions derived through feature movement than those derived through overt category movement" (Van der Meulen 2004:133).
- Feature movement (Chomsky 1995), however, cannot account for the absence of an 'IP-effect', e.g. in NEG-shift.
- Both *wh*-a/symmetries and lack of 'IP-effect' are easily accounted for with the Domain Hypothesis.

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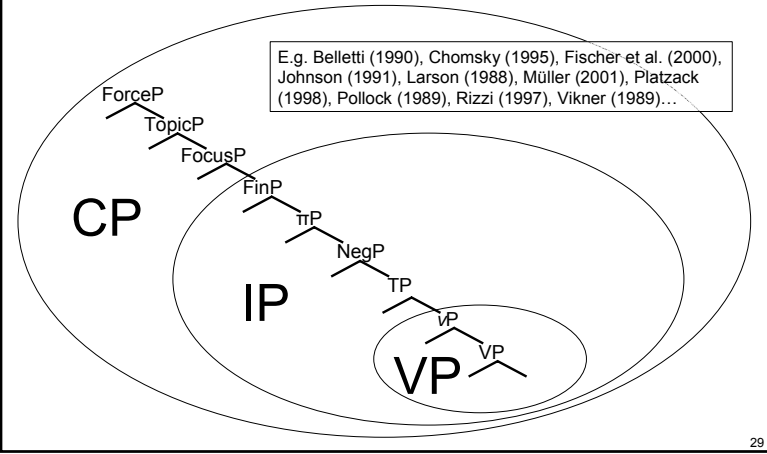
*Reanalysis of stimulus data.

- Other imaging studies
 - based on different theoretical approaches
 - but with compatible results
- Required: syntactic (re)analysis

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Articulate domains

E.g. Belletti (1990), Chomsky (1995), Fischer et al. (2000), Johnson (1991), Larson (1988), Müller (2001), Platzack (1998), Pollock (1989), Rizzi (1997), Vikner (1989)...



Difficulty/non-canonicity: Röder et al. (2002)

Jetzt wird **der** **Astronaut dem** **Forscher den** **Mond** beschreiben
 Now will the.NOM astronaut the.DAT scientist the.ACC moon describe
 Adv Aux Subj IO DO Verb

"Easy":

- A. [_{CP} Adv Aux [_{IP} **Subj** **IO DO** Verb]]
- B. [_{CP} Adv Aux [_{IP} **Subj DO IO t** Verb]]

"Difficult":

- C. [_{CP} Adv Aux **DO IO** [_{IP} **Subj t t** Verb]]
- D. [_{CP} Adv Aux **IO DO** [_{IP} **Subj t t** Verb]]

CD>AB → Broca

Working memory: Fiebach et al. (2005)

Thomas fragt sich
 Thomas asks SELF

wen **der** **Doktor am Dienstag nachmittag nach dem Unfall** verständigt hat
 who.ACC the.NOM doctor on Tuesday afternoon after the accident informed has
 Obj Subj Adv1 Adv2 Verb Aux

"Short-object"

- A. [_{CP} *wh-Obj* [_{IP} **Subj Adv1 Adv2** [_{VP} *t* Verb Aux]]]

"Long-object"

- B. [_{CP} *wh-Obj* **Adv1 Adv2** [_{IP} **Subj t t** [_{VP} *t* Verb Aux]]]

B>A → Broca

("Short/Long" = Obj-Subj distance, "object"=Obj-question)

Working memory: Fiebach et al. (2005)

Thomas fragt sich
 Thomas asks SELF

wer den **Doktor am Dienstag nachmittag nach dem Unfall** verständigt hat
 who.NOM the.ACC doctor on Tuesday afternoon after the accident informed has
 Subj Obj Adv1 Adv2 Verb Aux

"Short-subject"

- C. [_{CP} **wh-Subj** [_{IP} *t* Obj **Adv1 Adv2** [_{VP} *t* Verb Aux]]]

"Long-subject"

- D. [_{CP} **wh-Subj** [_{IP} *t* **Adv1 Adv2** [_{VP} Obj Verb Aux]]]

D>C → ∅

("Short/Long" = Obj-Subj distance, "subject"=Subj-question)

Movement of pronominals

- Target of pronoun movement: π P in the IP-domain
(Müller 2001:289; μ P: Johnson 1991, Platzack 1998:137; FP: Fischer et al. 2000:125)

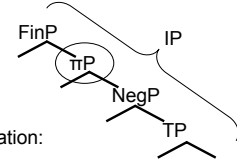
- German pronoun scrambling
 - *The Wackernagel Position*

- Scandinavian Object Shift
 - Targets a position between Subj and negation:

[_{CP} Verb_{fin} [_{FinP} Subj [(pron-Obj) [_{NegP} Neg [_{TP} (DP-Subj) (DP-Obj)...]]]]

- Middle English subject asymmetry
 - Full-DP Subj can remain low, but pronominal Subj must precede negation:

[_{CP} Verb_{fin} [_{FinP} (pron-Subj) [_{NegP} Neg [_{TP} (DP-Subj) ...]]]]



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Conflicting constraints

- Germanic (at least): The Subject Requirement
 - Spec-IP (spec-FinP) must be filled:
 - Clauses must have subjects.
 - The uninterpretable EPP-feature on I°/Fin° must be checked.
- German: Constraints on linear order
 - Pronominal arguments precede non-pronominal arguments
 - Pron > Full-DP
 - Linear order has higher priority than (overt) subject movement to spec-IP.
 - Pron > Full-DP >> “unambiguous encoding of subjecthood”

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Linearization: Grewe et al. (2005)

Dann hat **der** Lehrer dem Gärtner den Spaten gegeben
The has the.NOM teacher the.DAT gardener the.ACC spade given

Scrambling below Subj = inside IP:

A. [_{CP} Dann hat [_{FinP} [_{IO} pron [_{TP} Subj t _{IO} DO gegeben]]]	} B>A→∅
B. [_{CP} Dann hat [_{FinP} Subj _{pron} [_{TP} t _{Subj} IO DO gegeben]]]	
C. [_{CP} Dann hat [_{FinP} Subj [_{TP} t _{Subj} IO DO gegeben]]]	

} C>B→∅

} D>C→Broca

Scrambling above Subj = into CP:

D. [_{CP} Dann hat IO [_{FinP} Subj [_{TP} t _{Subj} t _{IO} DO gegeben]]]	} E>D→∅
E. [_{CP} Dann hat [IO DO] [_{FinP} Subj [_{TP} t _{Subj} t _{IP} gegeben]]]	

(My structural analysis)

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Linearization: Bornkessel et al. (2005)

Gestern wurde erzählt...
Yesterday was told

- “Active”: Scrambling above Subj = into CP:

A. [_{CP} dass [_{IP} der Junge [_{VP} den Lehrer _{the.DAT} hilft]]]]	} B>A→Broca
B. [_{CP} dass dem Jungen [_{IP} die Lehrer _{the.NOM} t _{VP} helfen]]]]	

- **Problem:**
With “Obj-Exp” psych verbs the **reverse pattern** is observed – though not significantly (i.e. only a tendency):

C. ...dass der Junge den Lehrern auffällt	} D<C → ∅/(Broca)
D. ...dass dem Jungen die Lehrer auffallen	

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Paradox

- No AGENT or “ACTOR”
 - The DAT argument is not inserted highest, in spec-vP (the AGENT position).
 - Indeed, the object of *auffallen* ‘notice’ need not be active or even alive
 - ...weil er schlief ‘...because he was asleep’
 - ...weil er tot war ‘...because he was dead’
- The NOM Experiencer (the ‘noticer’) agrees with verb
 - It is the Subj in spec-IP
- Thus, in DAT-NOM, the DAT Obj must move above Subj into CP:

[_{CP} dass Obj.DAT [_{IP} Subj.NOM [_{VP} ... Verb]]]
- However, there is no **significant** difference in activation between DAT-NOM and NOM-DAT:
 - Conclusion: They both involve movement to CP.

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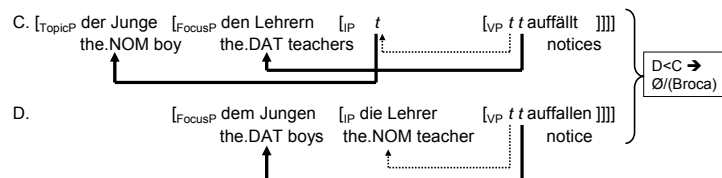
A solution: Focus

- Suggestion: The DAT Obj of a “Obj-Exp”-type psych verb is associated with a specific, strong feature.
 - Assume it to be [Focus]
- [Focus] is associated with FocusP in the CP-domain.
- The DAT Obj moves to spec-FocusP.
 - Thus, embedded clauses may also have articulate CP-domains.
 - See also the analysis of Icelandic Stylistic Fronting by Hrafnbjargason (2004).

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“Obj-Exp”-type psych verbs

Gestern wurde erzählt [_{CP} dass ...
Yesterday was told that

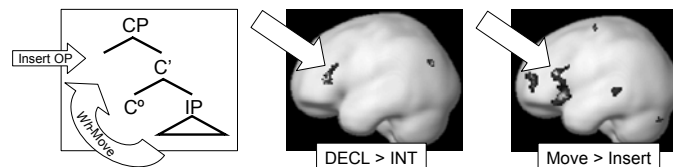


- Possible explanation of the markedness of NOM-DAT:
 - Topicalization under bridge-verb without V2.

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On the Broca tendency

- The (non-significant) activation tendency may thus reflect differences in the amount of movement to CP (rather than +/-)
- Christensen (2005, to appear):
 - Declaratives: 100% Movement to spec-CP (Subj)
 - Interrogatives: 50% Movement (wh-Obj), 50% OP-insertion



- 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 above Subj

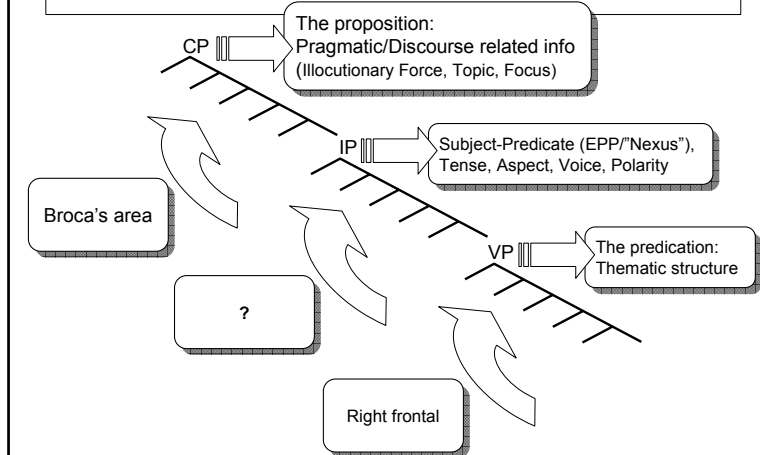
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Summary: the Domain Hypothesis

- The computational system interfaces with other cognitive systems during derivation
- Syntactic movement increases neural activation
- Activation patterns reflect structure-to-meaning mapping or *interfacing*
 - Dependent on different types of information
- **The crucial factor is**
 - neither *movement* nor *non-canonicity* per se,
 - but rather the target domain

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Summary: the Domain Hypothesis



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Thank you

References

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