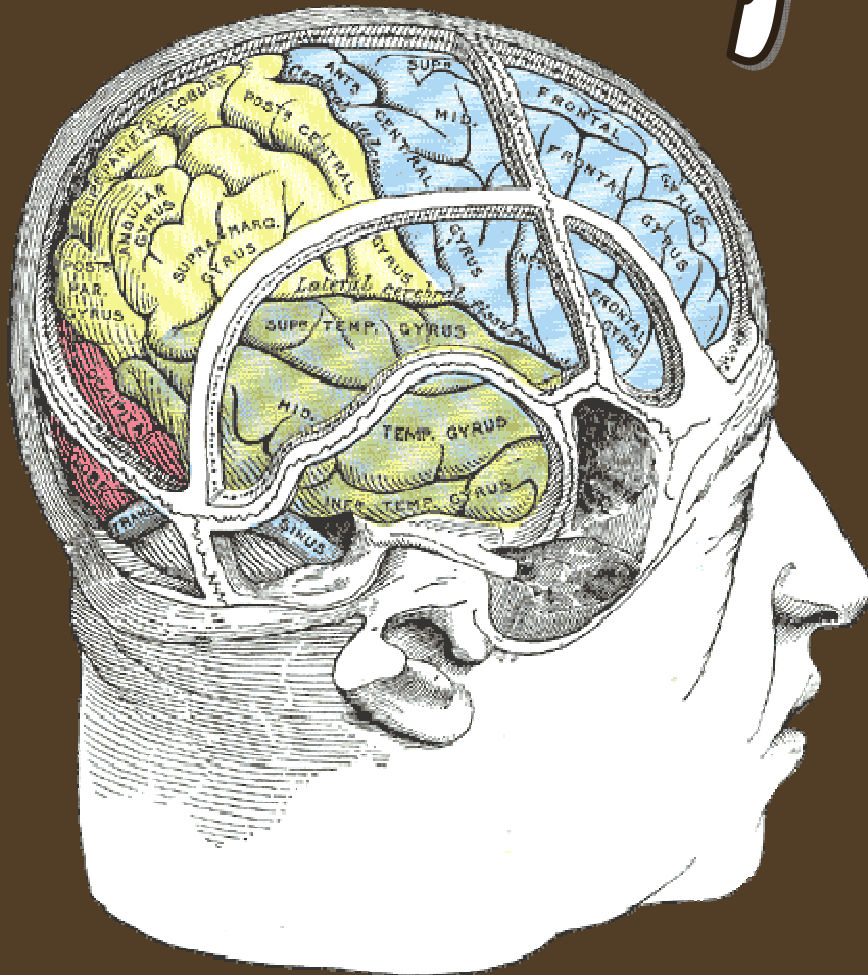


# Object Positions



# in the Brain

**Ken Ramshøj Christensen**

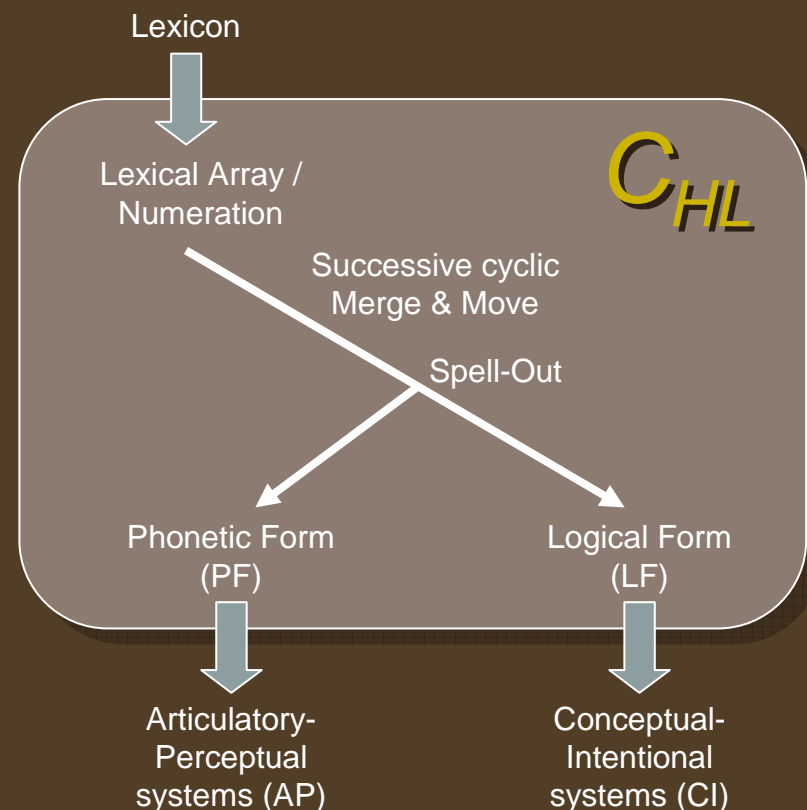
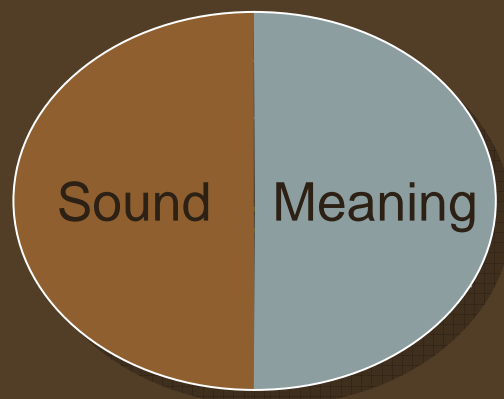
*Ph.D. course & workshop on  
Object Positions and Clause Structure  
Sandbjerg, Denmark, June 15, 2006*

# The language faculty

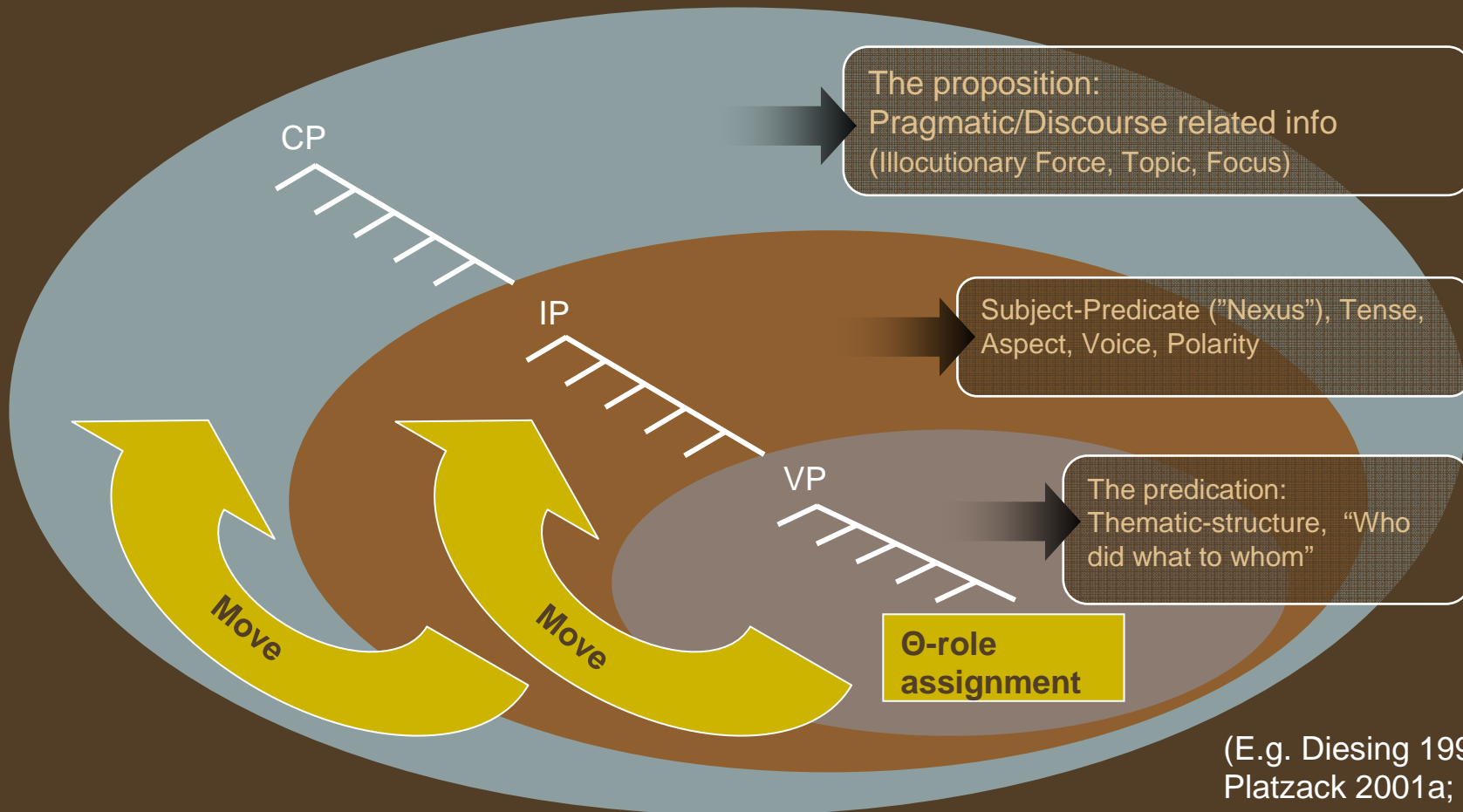
- I will assume here an approach to the study of language that takes the object of interest to be **an internal property of persons, a subcomponent of (mostly) the brain that is dedicated to language:**<sup>1</sup> the human “Faculty of Language.” (Chomsky 2004:104)
  - <sup>1</sup> “As a system, that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

# 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 2001, 2004, 2005, to appear).
- Cf. the Saussurean sign



# Structure-to-meaning mapping



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

# 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?** (Poeppe & Embick 2005)

# Modularity & implementation

- Modules may be found at all levels of description

## **Cognitive Modules:**

(Chomsky 2000)

- Face recognition
- Language

## **Input systems:**

(Fodor 1983)

- Perception

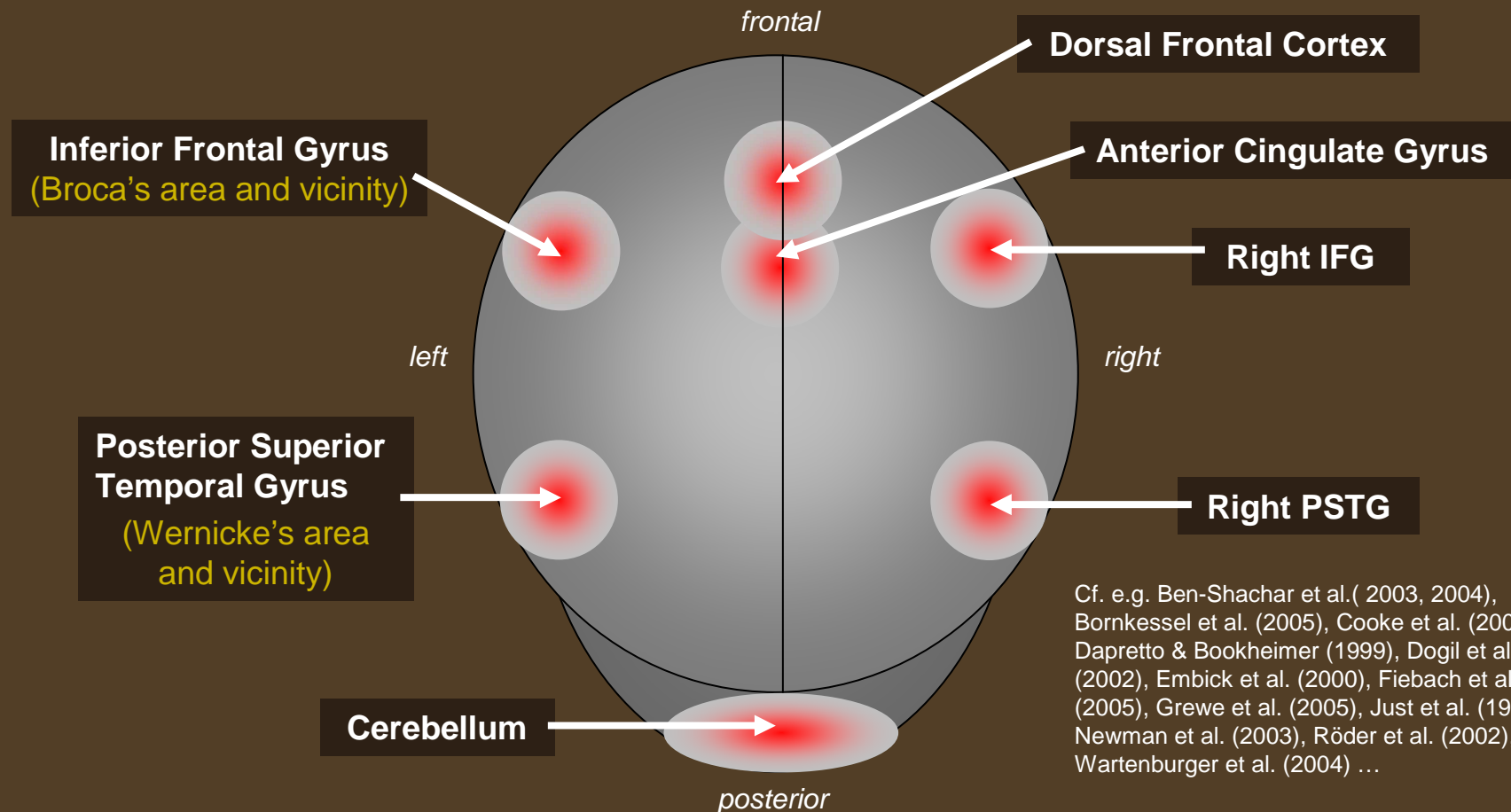
## **Cell Structure:**

- 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)

# The syntax Network

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



Cf. e.g. Ben-Shachar et al. (2003, 2004), Bornkessel et al. (2005), Cooke et al. (2001), Dapretto & Bookheimer (1999), Dogil et al. (2002), Embick et al. (2000), Fiebach et al. (2005), Grewe et al. (2005), Just et al. (1996), Newman et al. (2003), Röder et al. (2002), Wartenburger et al. (2004) ...

# 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).



# Basic questions

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

# 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)	<b>A: <u>NEG-shift</u></b> ingen NP <i>no</i>	<b>B: Neg Adv</b> <i>ikke (...nogen NP)</i> not any	Declarative
Spec-CP (CP-domain)	<b>C: <u>Wh-question</u></b> Hvilken NP <i>which</i>	<b>D: Yes/No question</b> OP Verb Subj	Interrogative

# 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.

# 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**<sub>[Neg]</sub> læst [**nogen**<sub>[Quant]</sub> bøger]  
*She has not read any books*

## (2) NEG-shift: Non-canonical OV

- Negation and quantification are realized on the same lexical item:

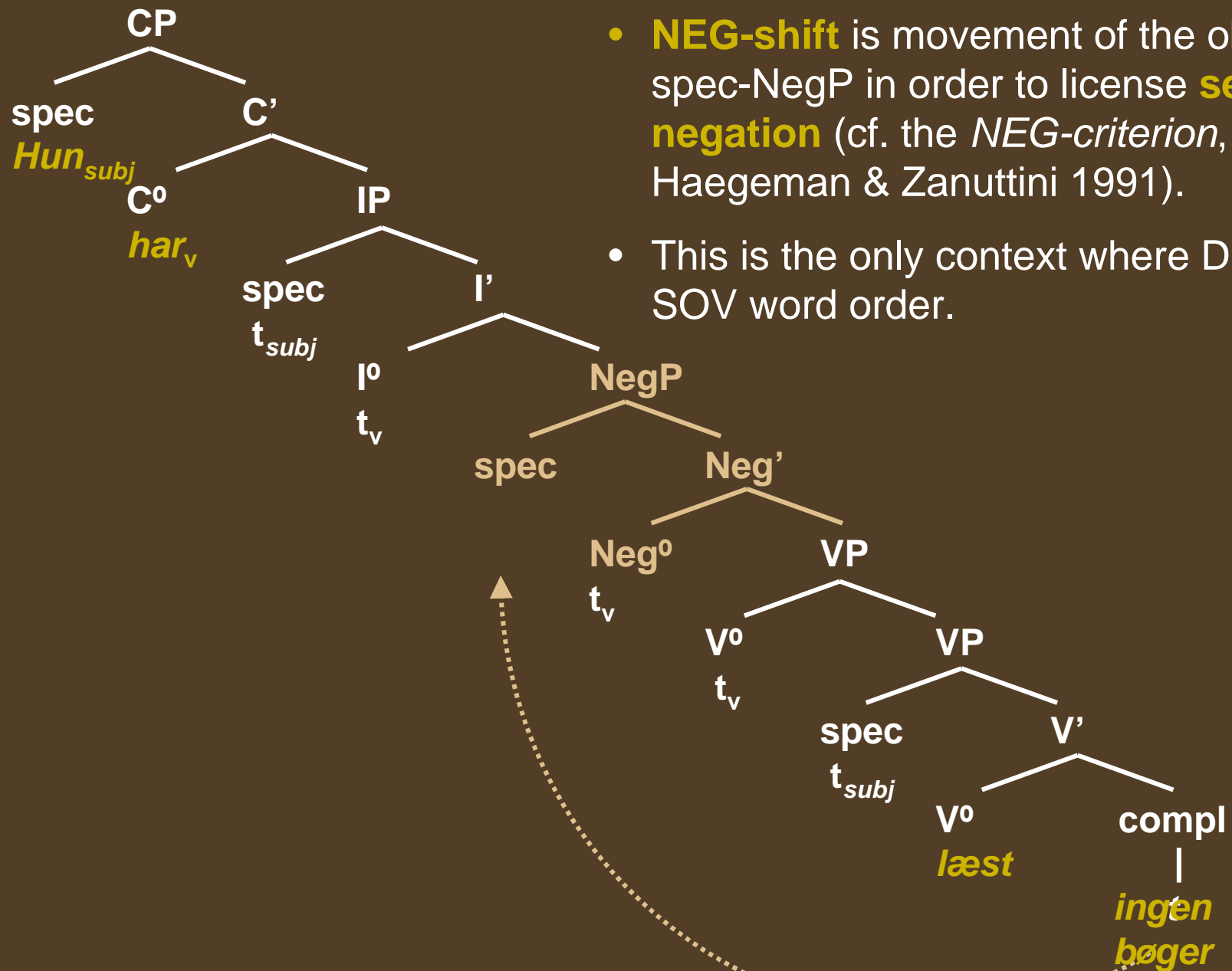
Hun har [**ingen**<sub>[Neg, Quant]</sub> bøger] læst  $t_{Obj}$   
*She has no books read*

# 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*

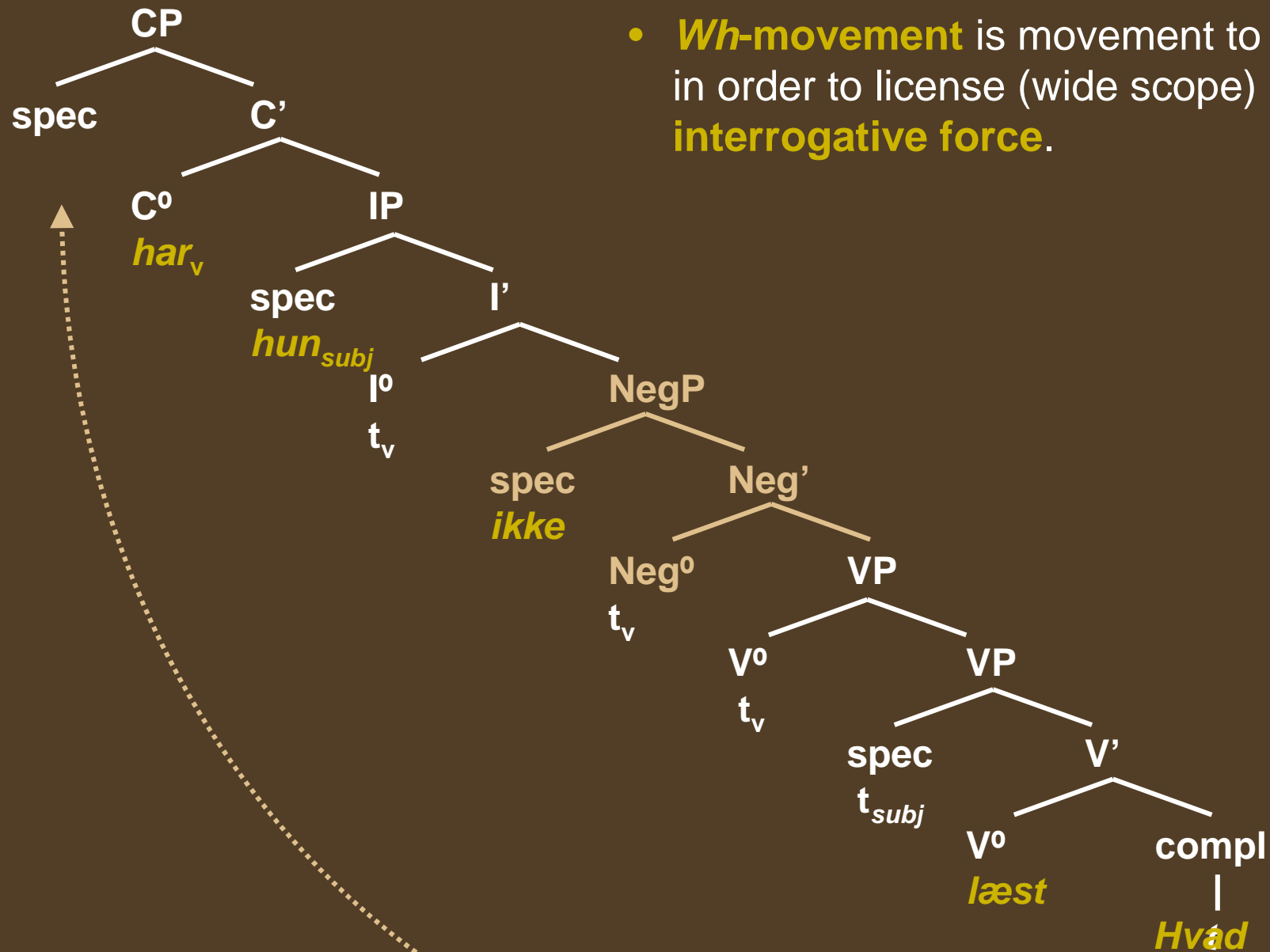
# Input: +/- *Wh*-movement

- 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*



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

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



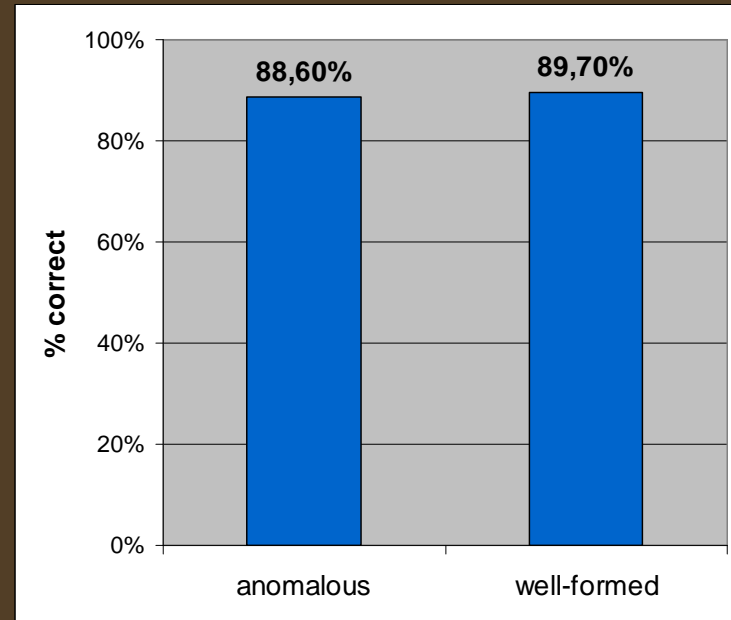


# Behavioural results

- **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.:

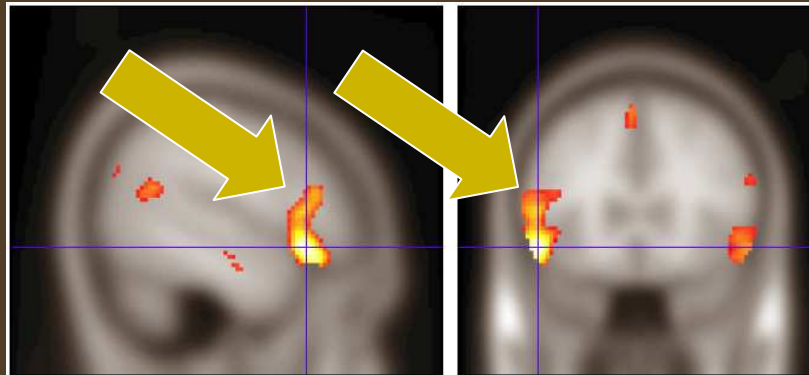
*The wife hasn't eaten any ideas*

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

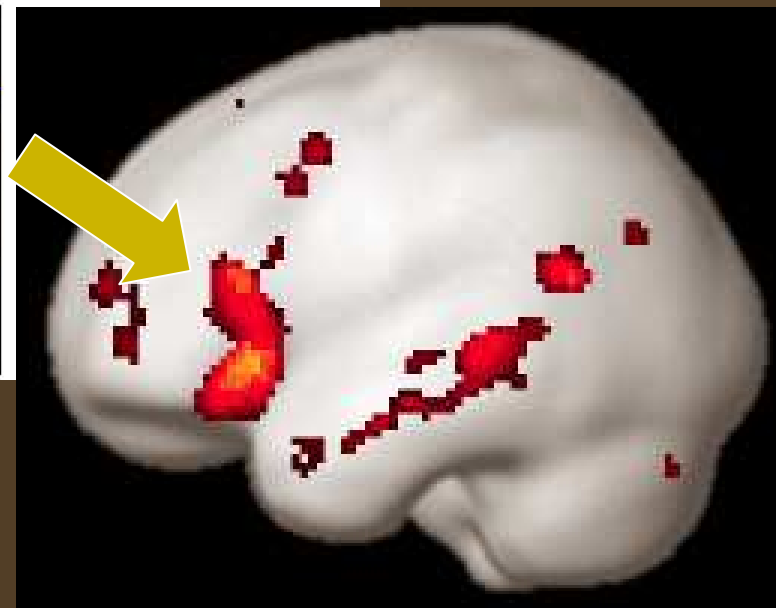
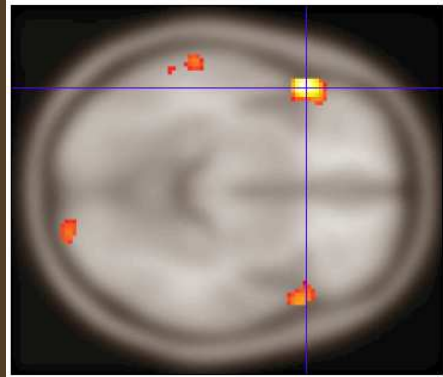


- There are also no significant differences in **reaction time** ( $p>0.23$ ) in any of the contrasts
  - No differences in task difficulty

# The CP-domain: *Wh*-Movement



Increased  
activation in  
**Broca's area**



# 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 (Bookheimer et al. 2005, Fiebach et al. 2005, Grewe et al. 2005, Röder et al. 2002)\*

\*Reanalysis of stimulus data

- 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...)

# The IP-domain: NEG-shift

No increased  
activation relative to  
non-movement...

# 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)\*

\*Reanalysis of stimulus data

- Lesion studies:
  - Negation is rarely affected in Broca’s aphasia (Hagiwara 1995, Lonzi & Luzzatti 1993, Bastiaanse et al. 2002)

# 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)

# *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

# 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.

[<sub>CP</sub> C<sup>0</sup> [<sub>IP</sub> Le garçon arrose **qui** ]]? (Obj in situ)  
 Q the boy splashes who (less impaired)  
 “Who does the boy splash (with water)?”

[<sub>CP</sub> **Qui** [<sub>C<sup>0</sup></sub> est-ce que] [<sub>IP</sub> le garçon arrose t ]]? (Obj moved)  
 Who Q the boy splashes (more impaired)

The diagram shows a bracket on the right side of the IP [le garçon arrose t] that extends upwards to the C<sup>0</sup> position 'est-ce que'. From there, an arrow points left to the CP position 'Qui', indicating the movement of the trace 't' to the specifier position.

[<sub>CP</sub> **Qui** [<sub>C<sup>0</sup></sub> (est-ce qui)] [<sub>IP</sub> t arrose le garçon ]]? (Subj moved)  
 Who Q splashes the boy (more impaired)  
 “Who splashes the boy (with water)?”

The diagram shows a bracket on the right side of the IP [t arrose le garçon] that extends upwards to the C<sup>0</sup> position '(est-ce qui)'. From there, an arrow points left to the CP position 'Qui', indicating the movement of the trace 't' to the specifier position.



# 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:

[<sub>CP</sub> Who does [<sub>IP</sub> Mary love t ] ] (Obj moved)  
↑ (impaired)


[<sub>CP</sub> Who C<sup>0</sup> [<sub>IP</sub> t loves Mary ] ] (Subj moved)  
↑ (impaired)

# 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.

I see the man... / It's the man...

[<sub>CP</sub> Who C<sup>0</sup> [<sub>IP</sub> Mary loves t ]]



(Obj moved)  
(more impaired)

[<sub>CP</sub> C<sup>0</sup> [<sub>IP</sub> Who loves Mary ]]

(Subj in situ)  
(less impaired)

# Agrammatism: van der Meulen (2004)

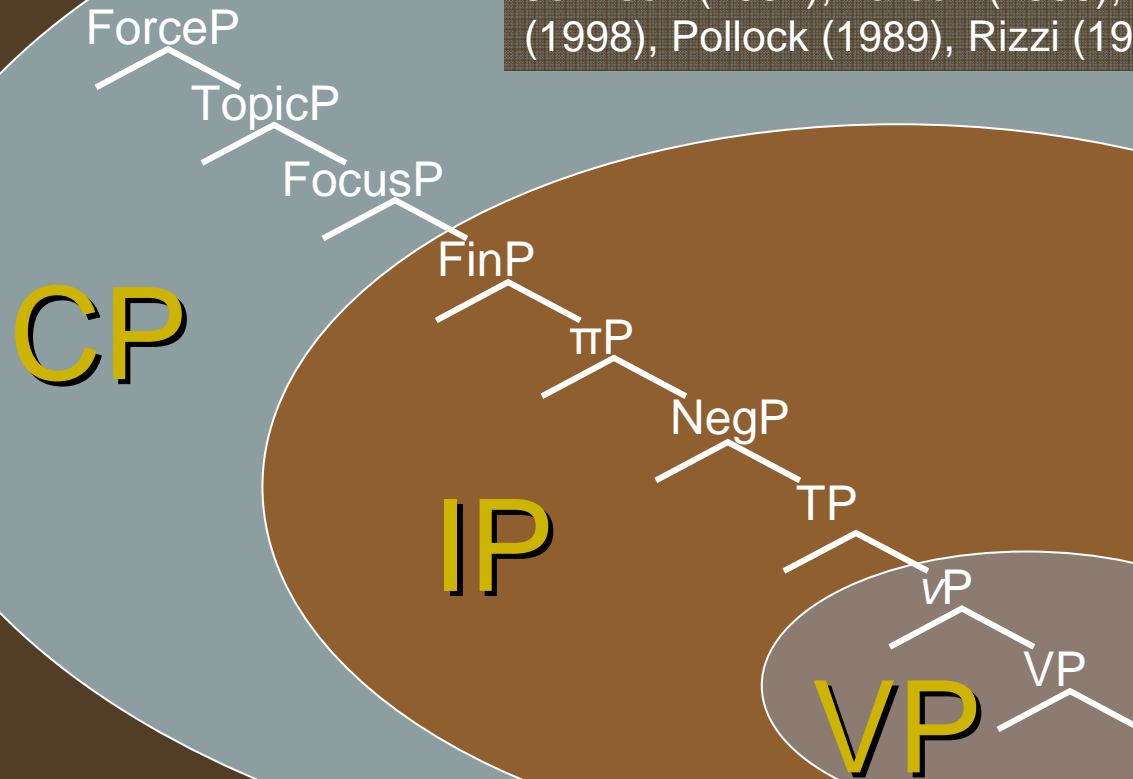
- “Broca patients have less difficulty comprehending constructions derived through feature movement than those derived through overt category movement” (Van der Meulen 2004:133).
- Feature movement (Chomsky 1995), however, cannot account for the absence of an ‘IP-effect’, e.g. in NEG-shift.
- Both *wh*-a/symmetries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

# \*Reanalysis of stimulus data.

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

# 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”:

*Scrambling below Subj = inside IP*

A. [<sub>CP</sub> Adv Aux [<sub>IP</sub> **Subj** **IO** **DO** Verb]]

B. [<sub>CP</sub> Adv Aux [<sub>IP</sub> **Subj** **DO** **IO** *t* Verb]]

“Difficult”:

*Scrambling above Subj = into CP*

C. [<sub>CP</sub> Adv Aux **DO** **IO** [<sub>IP</sub> **Subj** *t* *t* Verb]]

D. [<sub>CP</sub> Adv Aux **IO** **DO** [<sub>IP</sub> **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. [<sub>CP</sub> *wh-Obj* [<sub>IP</sub> **Subj** **Adv1** **Adv2** [<sub>VP</sub> *t* Verb Aux ]]]

“Long-object”

*Scrambling above Subj = into CP*  
 B. [<sub>CP</sub> *wh-Obj* **Adv1** **Adv2** [<sub>IP</sub> **Subj** *t* *t* [<sub>VP</sub> *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*

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

“Short-subject

*Scrambling below Subj = inside IP*

C. [<sub>CP</sub> **wh-Subj** [<sub>IP</sub> *t* **Obj Adv1 Adv2** [<sub>VP</sub> *t* Verb Aux ]]]

“Long-subject”

D. [<sub>CP</sub> **wh-Subj** [<sub>IP</sub> *t* **Adv1 Adv2** [<sub>VP</sub> Obj Verb Aux ]]]

D>C→∅

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

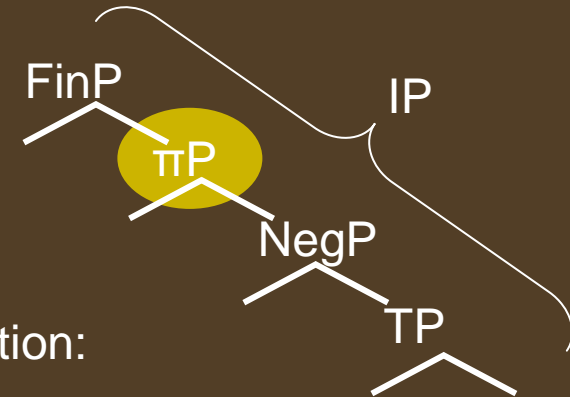


# Movement of pronominals

- Target of pronoun movement:  $\pi$ P in the IP-domain  
(Müller 2001:289;  $\mu$ 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:



[<sub>CP</sub> Verb<sub>fin</sub> [<sub>FinP</sub> Subj [(pron-Obj) [<sub>NegP</sub> Neg [<sub>TP</sub> (DP-Subj) (DP-Obj)...]]]]]

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

[<sub>CP</sub> Verb<sub>fin</sub> [<sub>FinP</sub> (pron-Subj) [<sub>NegP</sub> Neg [<sub>TP</sub> (DP-Subj) ...]]]]]

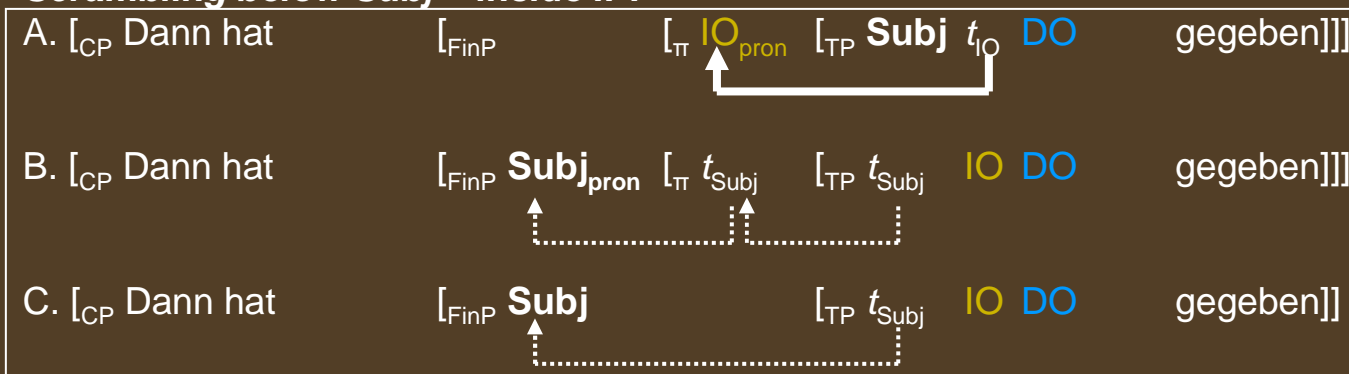
# Conflicting constraints

- Germanic (at least): The Subject Requirement
  - Spec-IP (spec-FinP) must be filled:
    - Clauses must have subjects.
    - The uninterpretable EPP-feature on  $I^0$ /Fin $^0$  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”

# 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:



B>A→∅

C>B→∅

D>C→Broca

## Scrambling above Subj = into CP:



E>D→∅

(My structural analysis)

# Linearization: Bornkessel et al. (2005)

Gestern wurde erzählt...  
*Yesterday was told*

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

A. [<sub>CP</sub> dass [<sub>IP</sub> **der** **Junge** [<sub>VP</sub> den Lehrern hilft ]]]  
*that the.NOM boy the.DAT teachers helps*

B. [<sub>CP</sub> dass dem Junge [<sub>IP</sub> **die** **Lehrer** [<sub>VP</sub> t helfen ]]]  
*that the.DAT boy the.NOM teachers help*

} B>A → Broca

- **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  
*that the.NOM boy the.DAT teachers notices*

D. ...dass dem Jungen **die** **Lehrer** auffallen  
*that the.DAT boys the.NOM teacher notice*

} D<C → ∅/(Broca)

# 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 schlaf* ‘...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:  
$$[_{CP} \text{dass } \text{Obj.DAT} [_{IP} \text{Subj.NOM} [_{VP} \dots \text{Verb} ]]]$$

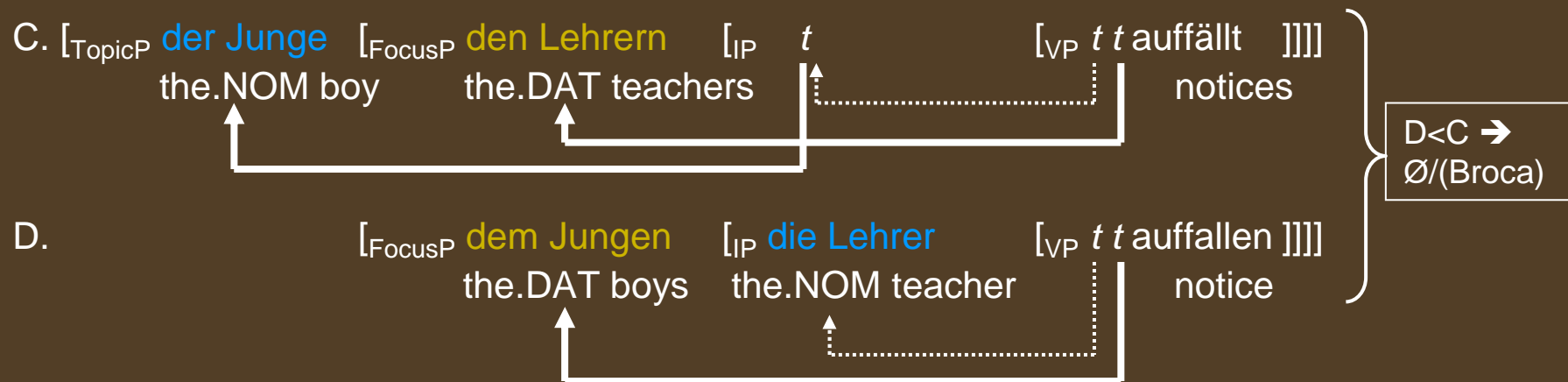
The diagram shows a syntactic tree structure. The root node is CP, containing the word 'dass'. Below CP is the IP node, which contains 'Obj.DAT' (highlighted in yellow) and 'Subj.NOM' (highlighted in blue). Below IP is the VP node, which contains '...' and 'Verb'. A white arrow points from the 'Obj.DAT' position in the IP branch up to the 'Obj.DAT' position in the CP branch, indicating movement.
- However, there is no **significant** difference in activation between DAT-NOM and NOM-DAT:
  - **Conclusion: They both involve movement to CP.**

# 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 Hrafnbjargarson (2004).

# “Obj-Exp”-type psych verbs

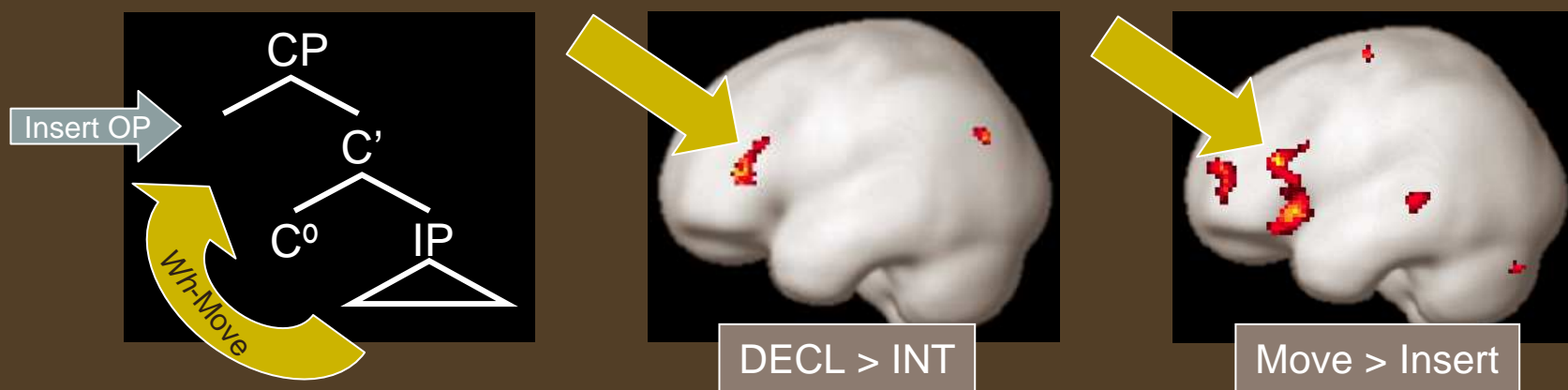
Gestern wurde erzählt [CP dass ...  
 Yesterday was told that



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

# 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**

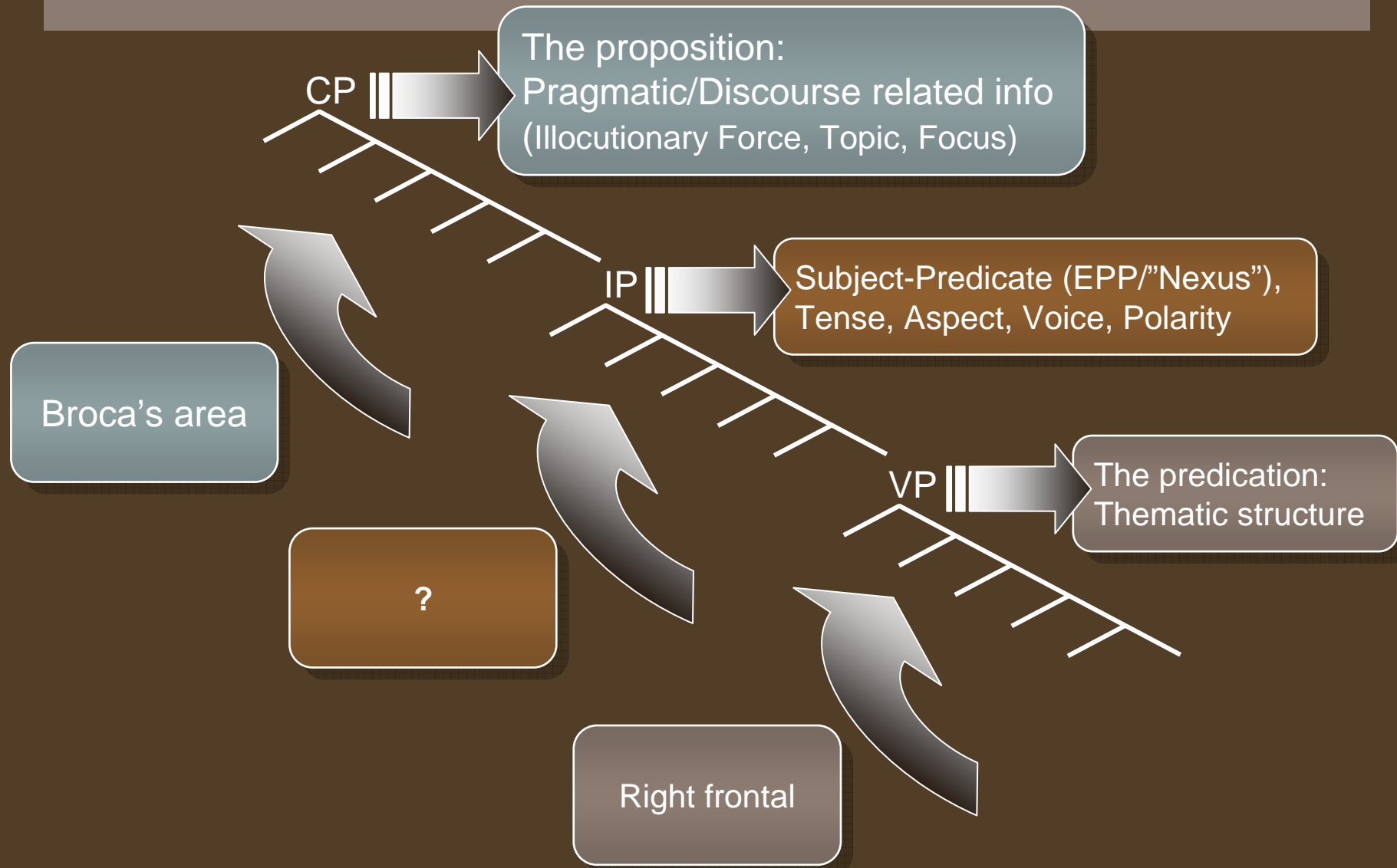


# Summary: the Domain Hypothesis

- 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**

# Summary: the Domain Hypothesis



Thank you



# References

- Bastiaanse, R., J. Rispens, E. Ruigendijk, O.J. Rabadán & C. Thomson (2002) Verbs: some properties and their consequences for agrammatic Broca's aphasia. *Journal of Neurolinguistics* 15, 239-264.
- Belletti, A. (1990) *Generalized Verb Movement. Aspects of Verb Syntax*, Turin: Rosenberg & Sellier.
- Ben-Shachar, M., T. Hendler, I. Kahn, D. Ben-Bashat & Y. Grodzinsky (2003) The Neural Reality of Syntactic Transformations: Evidence from fMRI. *Psychological Science* 14.5, 433-440.
- Ben-Shachar, M., D. Palti & Y. Grodzinsky (2004) Neural correlates of syntactic movement: converging evidence from two fMRI experiments. *NeuroImage* 21, 1320-1336.
- Bornkessel, I., S. Zysset, A.D. Friederici, Y. von Cramon & M. Schlesewsky (2005) Who did what to whom? The neural basis of argument hierarchies during language comprehension. *NeuroImage* 26, 221-233.
- Burchert, F., M. Swoboda-Moll & R. De Bleser. (submitted) The left periphery in agrammatic clausal representations: Evidence from German. *Journal of Neurolinguistics*.
- Chomsky, N. (1995) *The Minimalist Program*, Cambridge, Mass.: MIT Press.
- Chomsky, N. (2000) "Linguistics and Brain Science". In Marantz, A., Y. Miyashita & W. O'Neil (eds.) *Image, Language, Brain*, Cambridge, Mass.: MIT Press.
- Chomsky, N. (2001) "Derivation by Phase". In Kenstowicz, M. (ed.) *Ken Hale. A Life in Language*, Cambridge, Mass.: MIT Press, pp 1-52.
- Chomsky, N. (2004) "Beyond Explanatory Adequacy". In Belletti, A. (ed.) *Structures and Beyond. The Cartography of Syntactic Structures, Volume 3*, Oxford: Oxford University Press.
- Chomsky, N. (2005) Three Factors in Language design. *Linguistic Inquiry* 36.1, 1-22.
- Chomsky, N. (to appear) "On Phases". In Otero, C.P. et al. (eds.) *Foundational Issues in Linguistic Theory*, Cambridge, Mass.: MIT Press.

- Christensen, K.R. (2005) *Interfaces: Negation – Syntax – Brain*. PhD dissertation. Dept. of English, University of Aarhus.
- Christensen, K.R. (to appear) Interfaces, Syntactic Movement, and Neural Activation: A New Perspective on the Implementation of Language in the Brain. *Journal of Neurolinguistics*.
- Cooke A., E.B. Zurif, C. DeVita, D. Alsop, P. Koenig, J. Detre, J. Gee, M. Pinango, J. Balogh & M. Grossman (2001) Neural basis for sentence comprehension: grammatical and short-term memory components. *Human Brain Mapping* 15.2, 80-94.
- Dapretto, M. & S. Bookheimer (1999) Form and Content: Dissociating Syntax and Semantics in Sentence Comprehension. *Neuron* 24, 427-432.
- Diesing, M. (1997) Yiddish VP order and the typology of object movement in Germanic. *Natural Language and Linguistic Theory* 15.2, 369-427.
- Dogil, G., H. Ackermann, W. Grodd, H. Haider, H. Kamp, J. Mayer, A. Riecker & D. Wildgruber (2002) The speaking brain: a tutorial introduction to fMRI experiments in the production of speech, prosody and syntax. *Journal of Neurolinguistics* 15, 59-90.
- Embick, D., A. Marantz, Y. Miyashita, W. O'Neil & K.L. Sakai (2000) A syntactic specialization for Broca's area. *PNAS* 97.11, 6150-6154.
- Fiebach, C., Schlesewsky, M., Lohmann, G., von Cramon, D.Y. & Friederici, A.D. (2005) Revisiting the Role of Broca's Area in Sentence Processing: Syntactic Integration vs. Syntactic Working Memory. *Human Brain Mapping* 24, 79-91.
- Fischer, O., A. van Kemenade, W. Koopman & W. van der Wurff (2000) *The Syntax of Early English*, Cambridge: Cambridge University Press.
- Fodor, J. (1983) *The Modularity of Mind*, Cambridge, Mass.: MIT Press.
- Friederici, A.D., C.J. Fiebach, M. Schlesewsky, I. Bornkessel & D.Y. von Cramon (2006) Processing Linguistic Complexity and Grammaticality in the Left Frontal Cortex. *Cerebral Cortex*. (Page numbers refer to the online 'Advance Access' version.)
- Friedmann, N. (2003). The fragile nature of the left periphery: CP deficits in agrammatic aphasia. *Proceedings of the 18th IATL conference*.

- Friedmann, N. & Y. Grodzinsky (1997) Tense and Agreement in agrammatic production: Pruning the syntactic tree. *Brain and Language* 56, 397-425.
- Friston, K.J., C.J. Price, P. Fletcher, C. Moore, R.S.J. Frackowiak, & R.J. Dolan (1996) The Trouble with Cognitive Subtraction. *Neuroimage*, 4: 97-104.
- Grewe, T., I. Bornkessel, S. Zysset, R. Wiese, D.Y. von Cramon & M. Schlesewsky (2005). Emergence of the Unmarked: A New Perspective on the Language-Specific Function of Broca's Area. *Human Brain Mapping*, 26, 178-190.
- Grodzinsky, Y. (2000) The neurology of syntax: language use without Broca's area. *Behavioral and Brain Sciences* 23.1, 1-71.
- Haegeman, L. & R. Zanuttini (1991) Negative Heads and the NEG Criterion. *The Linguistic Review* 8, 233-251.
- Hagiwara, H. (1995). The breakdown of functional categories and the economy of derivation. *Brain and Language* 50, 92-116.
- Hrafnbjargarson, G.H. (2004) *Oblique Subjects and Stylistic fronting in the History of Scandinavian and English: The Role of IP-Spec*. Ph.D. dissertation, University of Aarhus.
- Jenkins, L. (2000) *Biolinguistics. Exploring the Biology of Language*, Cambridge: Cambridge University Press.
- Johnson, K. (1991) Object positions. *Natural Language and Linguistic Theory* 9, 577-636.
- Just, M.A., P.A. Carpenter, T.A. Keller, W.F. Eddy & K.R. Thulborn (1996) Brain Activation Modulated by Sentence Comprehension. *Science* 274, 114-116.
- Larson, R.K. (1988) On the Double Object Construction. *Linguistic Inquiry* 19, 335-391.
- Lonzi, L. & C. Luzzatti (1993) Relevance of Adverb Distribution for the Analysis of Sentence Representation in Agrammatic Patients. *Brain and Language* 45.3, 306-317.
- Müller, G. (2001) "Order Preservation, Parallel Movement, and the Emergence of the Unmarked" in: Legendre, G., J. Grimshaw & S. Vikner (eds.) *Optimality-theoretic Syntax*, Cambridge Mass.: MIT Press, pp. 279-313.
- Newman, S.D., M.A. Just, T.A. Keller, J. Roth & P.A. Carpenter (2003) Differential effects of syntactic and semantic processing on the subregions of Broca's area. *Cognitive Brain Research* 16, 297-307.

- Platzack, C. (1998) *Svenskans inre grammatik – det minimalistiska programmet. En introduktion till modern generativ grammatik*, Lund: Studentlitteratur.
- Platzack, C. (2001a) "Multiple Interfaces". In Nikanne, U. & E. van der Zee (eds.) *Cognitive Interfaces. Constraints on Linking Cognitive Information*, Oxford: Oxford University Press, pp. 21–53.
- Platzack, C. (2001b) The Vulnerable C-Domain. *Brain and Language* 77.3, 364-77.
- Poeppel, D. & D. Embick (2005) "Defining the relation between linguistics and neuroscience". In Cutler, A. (Ed.) *Twenty-first century psycholinguistics: Four cornerstones*. Mahwah, NJ: Lawrence Erlbaum Associates, Inc.
- Pollock, J.-Y. (1989) Verb movement, universal grammar, and the structure of IP. *Linguistic Inquiry* 20.3, 365-424.
- Rizzi, L. (1997) "The Fine Structure of the Left Periphery". In Haegeman, Liliane (ed.) *Elements of Grammar*, Dordrecht: Kluwer, pp. 281-337.
- Rizzi, L. (2004) On the study of the language faculty: Results, developments, and perspectives. *The Linguistic Review* 21.3-4, 323-344.
- Röder, B., O. Stock, H. Neville, S. Bien & F. Rösler (2002) Brain Activation Modulated by the Comprehension of Normal and Pseudo-word Sentences of Different Processing Demands: A Functional Magnetic Resonance Imaging Study. *NeuroImage* 15, 1003–1014.
- Saddy, D. & J. Uriagereka (2004) Measuring Language. *International Journal of Bifurcation and Chaos* 14.2, 383-404.
- Schneiderman, E. & D. Saddy (1988) A linguistic deficit resulting from right hemisphere damage. *Brain and Language* 34: 38-53.
- Van der Meulen, I. (2004). Syntactic movement and comprehension deficits in Broca's aphasia. PhD dissertation. Utrecht: LOT.
- Vikner, S. (1989) Object Shift and Double Objects in Danish. *Working Papers in Scandinavian Syntax* 44, 141-155.
- Wartenburger, I., H.R. Heekeren, F. Burchert, S. Heinemann, R. de Bleser & A. Villringer (2004) Neural Correlates of Syntactic Transformations. *Human Brain Mapping* 22, 72-81.