

Lecture 3: Grammar

Cognition, Language & Communication 2013

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Recap

- Duality of patterning and recursive hierarchical phrase-structure seem to be unique to human language
- Many of the other claimed 'unique design features' are shared, to some degree, with other animals, including arbitrariness, displacement, discreteness, stimulus freedom, vocal learning, cultural transmission and (a rudimentary form of) compositionality
- Combination of design features is certainly unique
- Difficult to get quantitative, precise statements about how different language is

Recap: Chomsky 1957

- Chomsky Hierarchy – birth of formal language theory
- Generative methodology: autonomy of syntax; grammaticality judgments; mathematical, generative models;
- Dismissal of statistical models (as a side-effect of dismissal of Markov models / finite-state automata)

FSA

- Finite-state automaton
- Simple abstract machine that generates strings;
- Machine can be in a finite number of distinct *states* (circles);
- From every state, the machine can move to a number of other states (arrows) – possible moves only dependent on the current state (no memory!);
- Each arrow is associated with the production of a word / letter / sound etc.

FSA's are inadequate

(Chomsky, 1957)

Let S_1, S_2, S_3, S_4, S_5 be simple declarative sentences in English. Then also

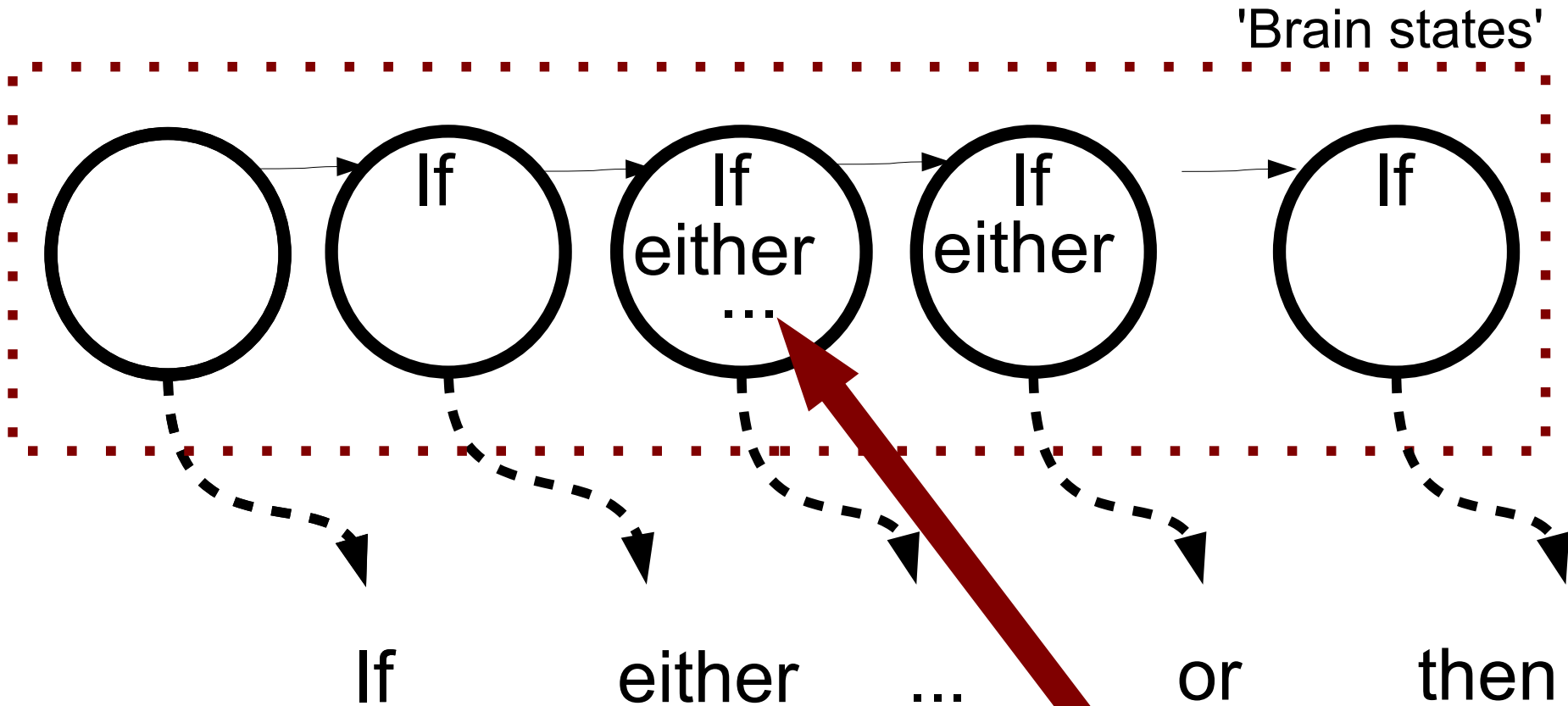
(2) If S_1 , then S_2 .

(3) Either S_3 or S_4 .

(4) The man who said that S_5 , is arriving today

are sentences of English.

E.g., if either you are with us or you are against us applies here, then there is nothing more to discuss.

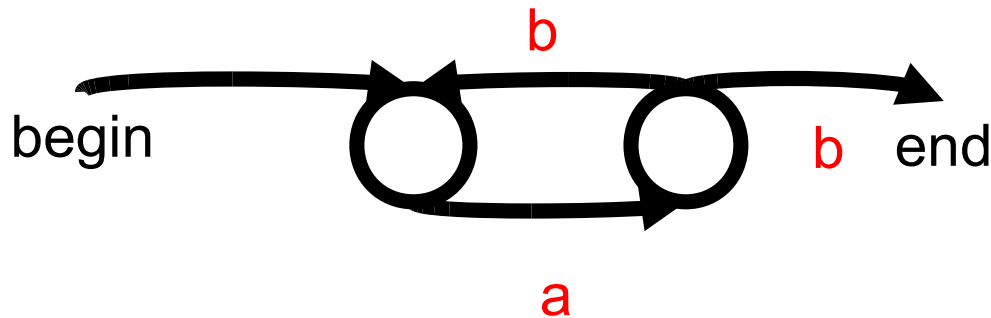


No principled bound on how much information must be kept in memory

Simplest example of a “finite-state language”:

$(ab)^n$

E.g. ab, abab, ababab, abababab



Simplest example of a “context-free language”:

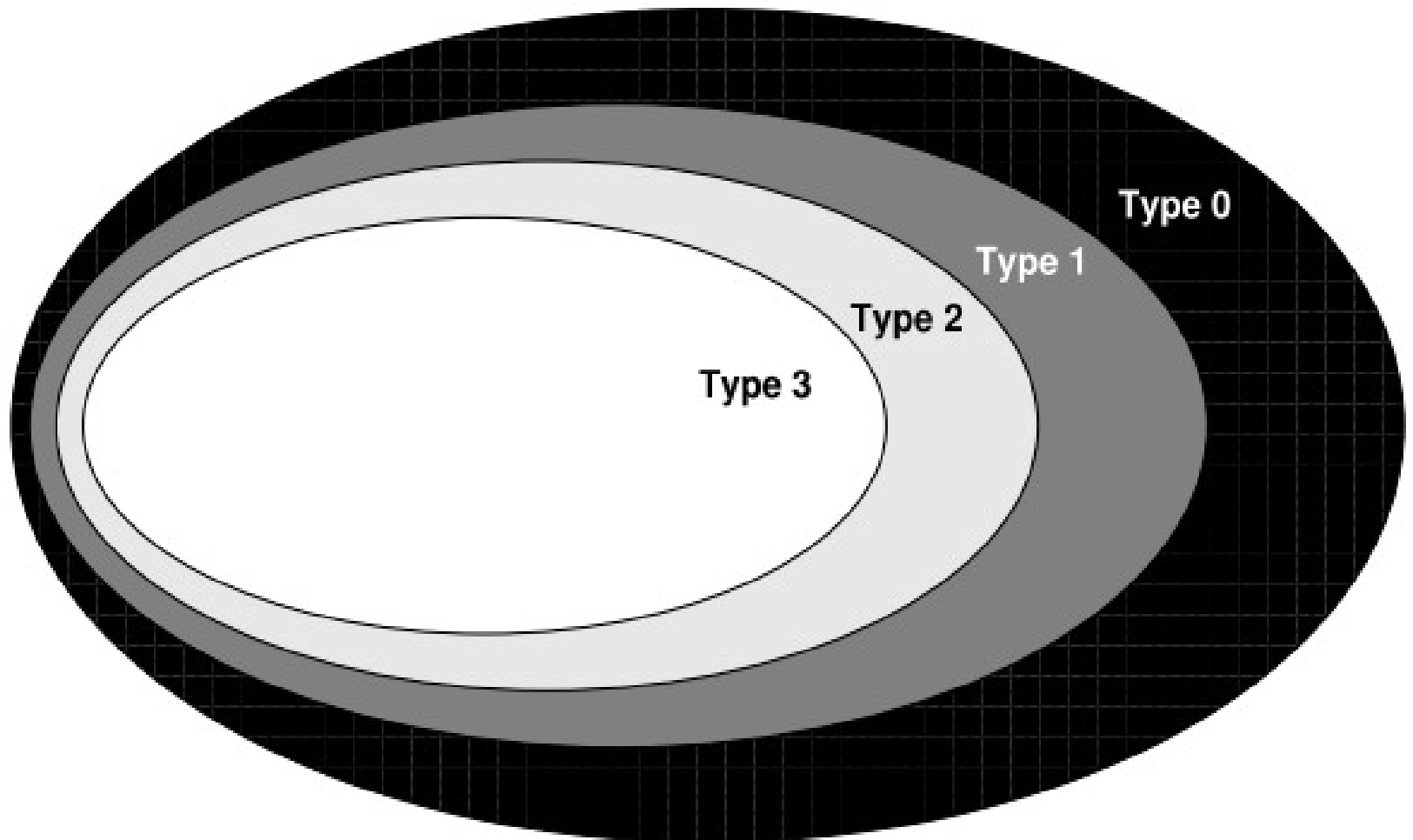
$a^n b^n$

E.g. ab, aabb, aaabbb, aaaabbbb, ...

Chomsky Hierarchy

3. Finite state grammars	$A \rightarrow a, A \rightarrow aB$	$(ab)^n, a^n b^m$
2. Context-free grammars	$A \rightarrow \gamma$	$a^n b^n$
1. Context-sensitive grammars	$\alpha A \beta \rightarrow \alpha \gamma \beta$	$a^n b^n c^n$
0. Unrestricted grammars	$\alpha \rightarrow \gamma$	$\{a^n b^m c^l \mid l = n * m\}$

The Chomsky Hierarchy

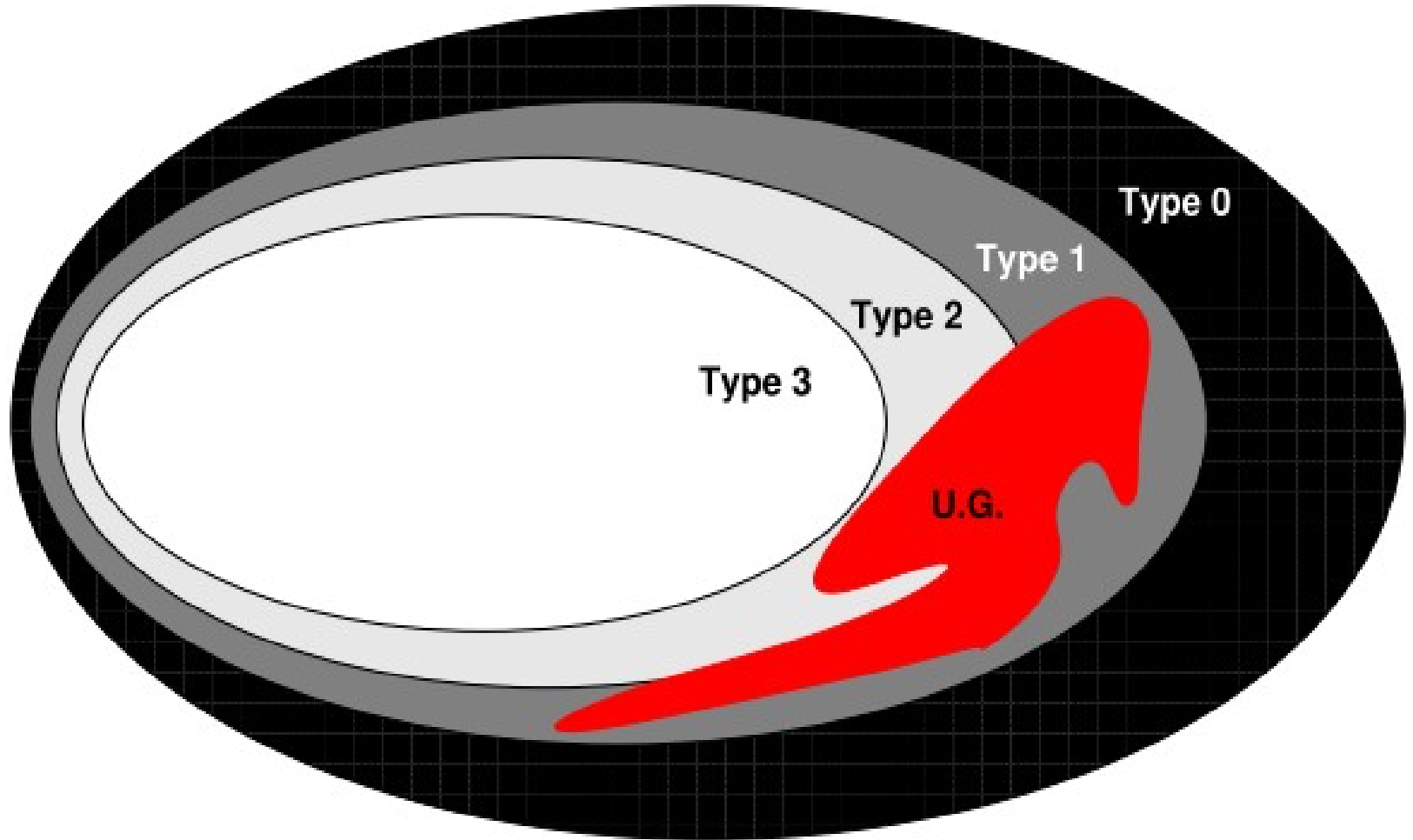


- (1) a. Gilligan claims that Blair deceived the public.
- b. Gilligan claims that Campbell helped Blair deceive the public.
- c. Gilligan claims that Kelly saw Campbell help Blair deceive the public.
 (tail recursion)

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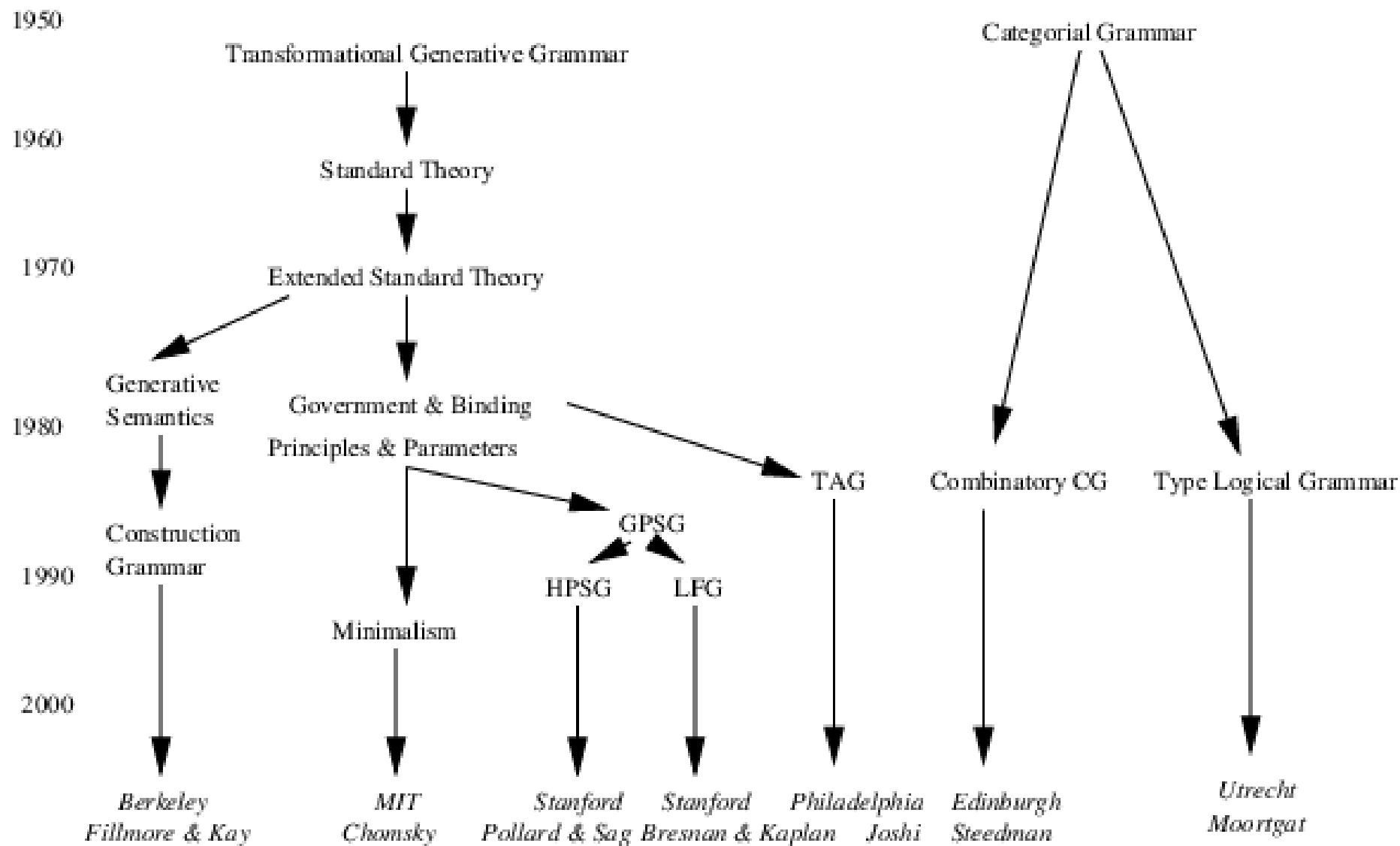
- (2) a. Gilligan behaupte dass Kelly Campbell Blair das Publikum belügen
 helfen sah. (center embedding)
- b. Gilligan beweert dat Kelly Campbell Blair het publiek zag helpen
 bedriegen. (crossing dependencies)

The Chomsky Hierarchy



Generative methodology

- Since 1957, theoretical linguistics has produced very many, increasingly sophisticated formalisms to account for native speaker grammaticality intuitions;
- Research on very many different languages – many claims of commonalities between languages;
- Chomsky soon (cf. 1959) concluded the complexity of linguistic processing requires us to assume structured internal states in the minds of language users – contra behaviorism
- A little later (1960s) Chomsky and colleagues also started to make the argument that it also requires us to assume innate knowledge of language – contra empiricism



Consensus & Controversies

- No-one wants to return to behaviorism,
 - but debate about nature of representations continues (symbolism – connectionism)
- No-one advocates blank-slate empiricism
 - but debate continues about whether there is *language-specific* innate knowledge
- (Almost) everyone accepts phrase-structure grammars are useful for describing languages
 - but skeptics deny that grammaticality should be a cornerstone, and that useful commonalities between languages have been discovered

Hierarchical structure

- Almost all language researchers accept that some form of hierarchical structure is real in all human languages
 - Debates about whether *phrase*-structure and recursion are universal
 - Debates about whether it is a purely syntactic property, or whether it derives from semantics.

Can animals process HS?

645. (C) *I want Kanzi to grab Rose.*

(Kanzi turns around and grabs Rose on the leg, then walks away.)

581. (C) *Kanzi, tell Rose that you want to go outdoors.*

(Kanzi turns, looks at Rose, and gestures toward the play-yard door.) Rose looks in that direction and says, “You’re supposed to go over there?” (Kanzi heads toward the play-yard door, and Rose follows.)

In all these cases, however, Kanzi’s responses would be identical if he ignored the upstairs clauses, and just responded to the most embedded clause.

428. (PC) *Give the water and the doggie to Rose.*

(Kanzi picks up the dog and hands it to Rose.)

526. (PC) *Give the lighter and the shoe to Rose.*

(Kanzi hands Rose the lighter, then points to some food in a bowl in the array that he would like to have to eat.)

281. (C) *Give me the milk and the lighter.*

(Kanzi does so.)

Kanzi's overall accuracy on the coordination construction is at chance level (25%).

Next class

- Computerlab on Thursday
- Reading: Chomsky 1967