

A Story about Learnability and Science

18.3.08

Azrieli Fellows Program

Credit: some slides and inspiration were used from a course by Alex Clark and Shalom Lappin in The Linguistic Institute, Stanford, 2007.

Outline

- Nativists vs. Empiricists
- Argument from the poverty of the stimulus
- Gold (1967)
- Critique
- Quoting Gold...

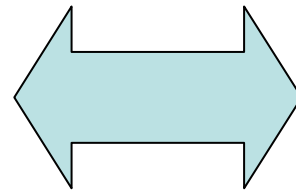
How do children acquire language?

- "There remains only the case of someone suggesting that speech is a natural action ... This is falsified ... if languages were imposed by the natures of places, then each place would have to have only the language imposed by its nature but the falsehood of this is plain to the eye..."

(Ibn-Hazm, ~ 1064 A.C)

How do children acquire language?

Empiricism

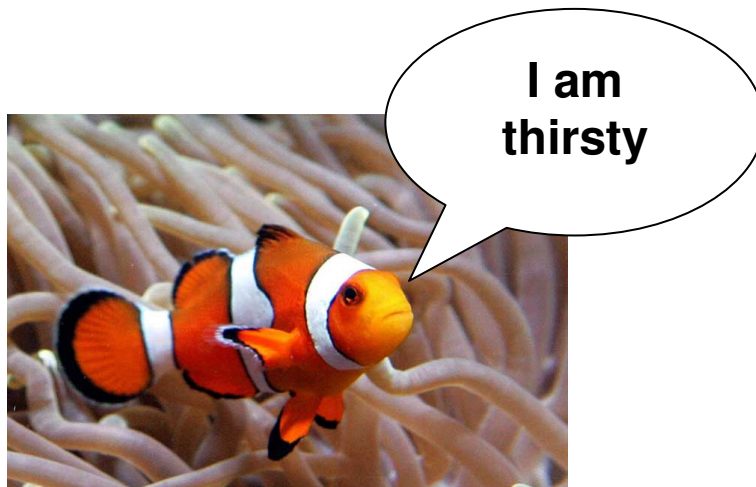


Nativism



A fact

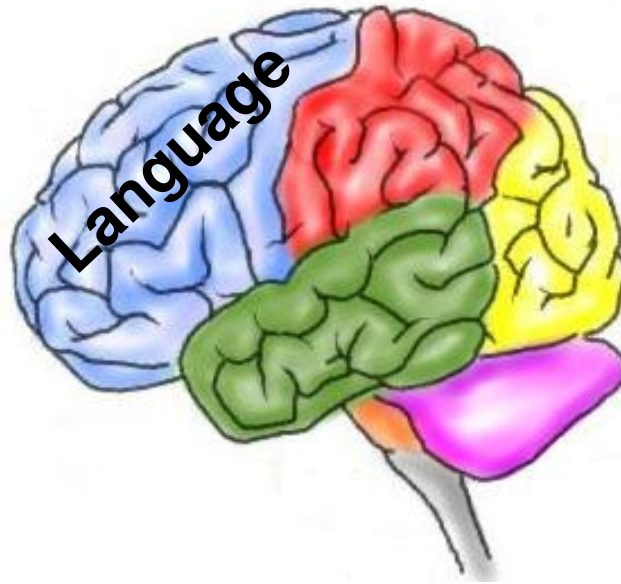
Fish can't talk. People can.



- Ergo, there is something innate, genetically determined, that allows us to acquire language. QED.

So why are we fighting?

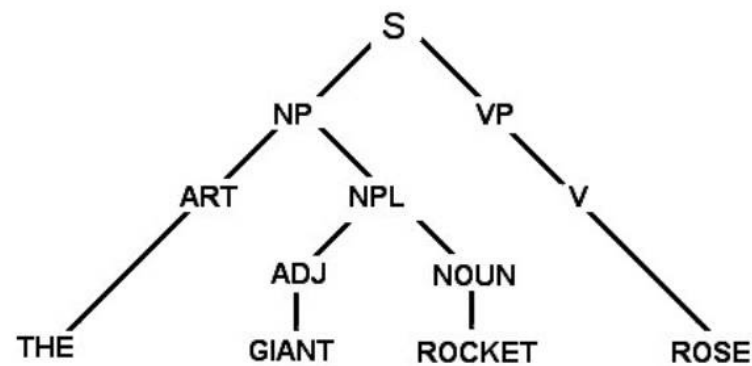
- Is this genetic endowment specific to language or cognitively general?



Language specific knowledge

It's on a continuum:

- Parts-of-speech
- Tree structures
- Head-Complement order



Key: ADJ: Adjective; ART: Article
NP; Noun Phrase S: Sentence; VP: Verb Phrase

Figure 2

Cognitively general principles

- Analogy
- Economy
- Induction
- Deduction
- Attention
- Efficiency
- Simplicity

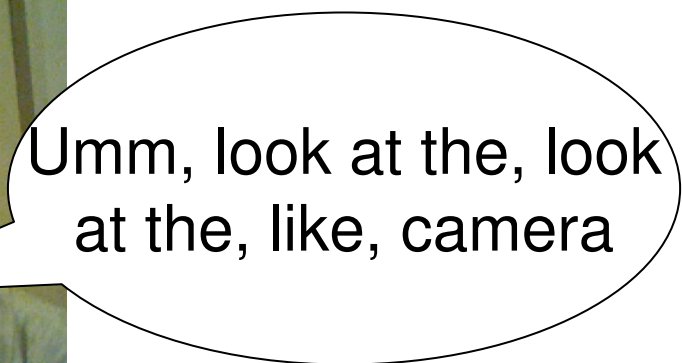
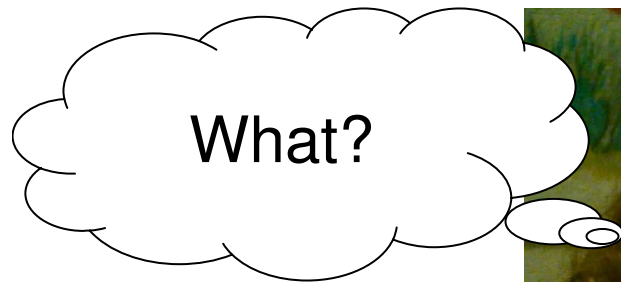


Argument from the poverty of the stimulus

- “The APS is the existence proof for the possibility of cognitive science” (Fodor, 1981)
- “The strongest most central arguments for innateness thus continue to be arguments from the poverty of the stimulus” (Wexler, 1999)

The argument - informally

- There is no way a child can learn from the noisy, incomplete, limited data available, unless it already has a lot of information about the structure of natural language.

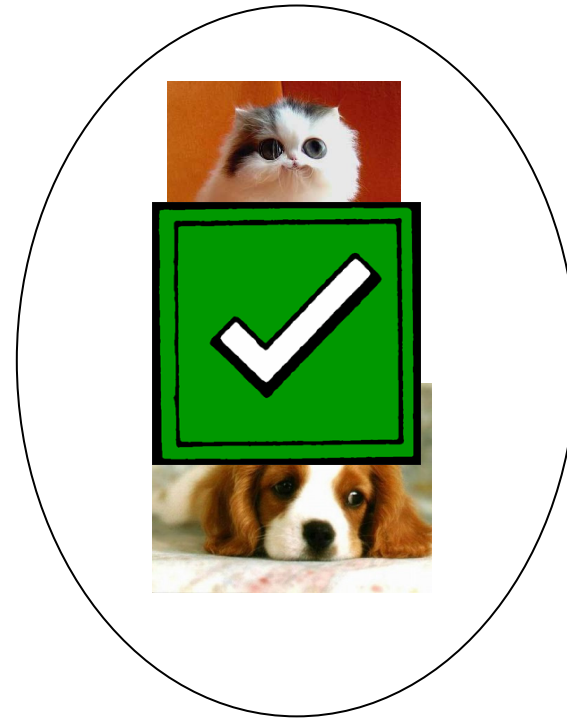
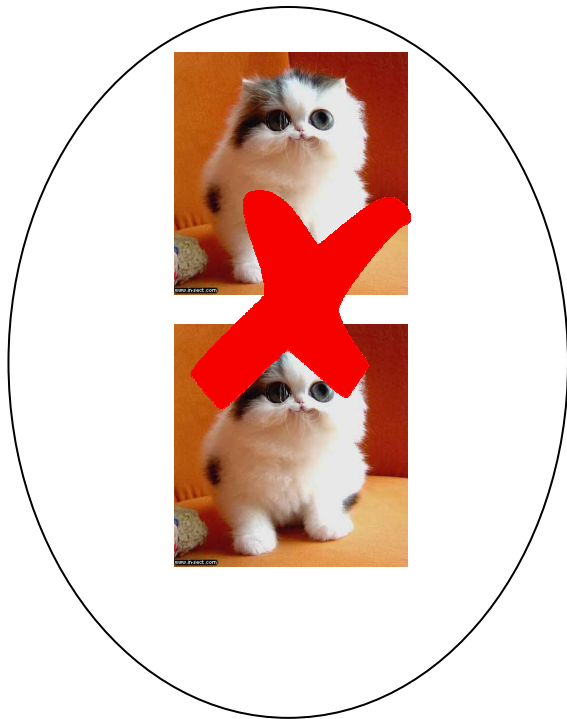


The argument – more formally

- A domain-neutral algorithm that could learn natural language from the child's input **can not be devised.**
- Are there any mathematical reasons to believe that?

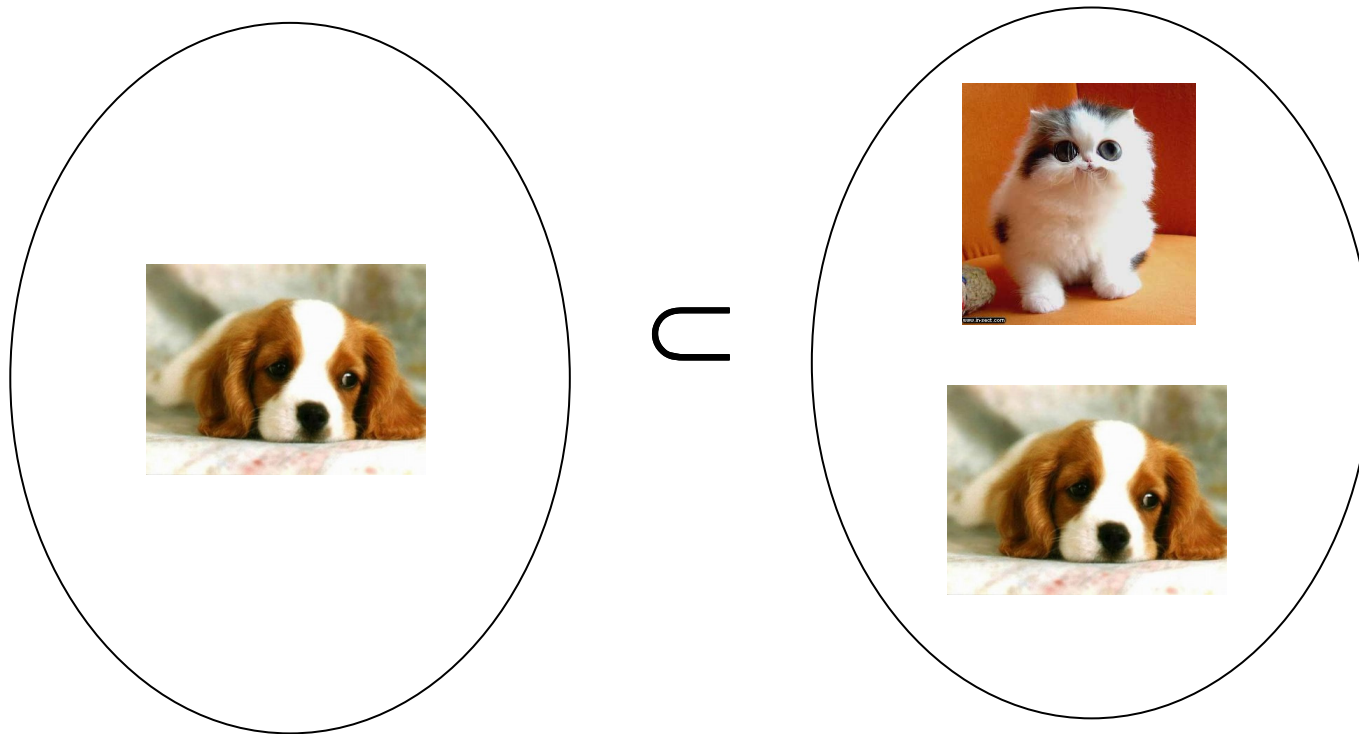
Definitions - what is a set?

- Set: collection of distinct unordered objects



Definitions – what is a subset?

- We denote $A \subset B$ if every member of A is a member of B



Definitions – what is a language?

- Alphabet – a finite set of symbols: $\{a,b,\dots,z\}$
- Sentence – a finite concatenation of symbols from an alphabet: ‘I love lucy’, ‘aB pQr ssdlkjh’
- Language – a finite or infinite set of sentences
 - Yan
 - Yan-tzidran
 - Yan-tzidran-tzidroni
- Class – a finite or infinite set of languages:
{English, Hebrew, Bengali, French, Quechua...}

Definitions – what is the learning process?

- We take a class of languages C
- We choose somehow a language L from the class C
- We give a learner sentences from L one by one. Every sentence will appear at some point.
- After every point the learner tries to guess the language L

Definitions – what is successful learning?

- Learning is successful if at some point the learner guesses the correct language L and doesn't change this guess anymore given new sentences.

We have now formally defined (maybe in a bad way) what learning means

Gold proved:

A set containing all of the finite languages (there are infinitely many) and at least one infinite language is:

Unlearnable



Sketchy proof - reshut

- $L = \{s_1, s_2, s_3, \dots \text{forever}\}$ is infinite.
- There is a chain $L_1 \subset L_2 \subset L_3 \subset \dots L$.
- Let's assume that there is a learner H that can learn L :
- We will show s_1 until he guesses L_1 , then s_2 until he guesses L_2 , s_3 until he guesses L_3 , etc.
- The learner will never guess L !!!!
- Contradiction! Woohoow!

Corollary

- It is assumed that the class of natural languages is the class of context-free languages (not really true, but let's not talk about this)
- This class contains all of the finite languages and a lot of infinite languages
- **So natural languages are unlearnable**

Are they?

It's a bad model – why?

- Are natural languages suprafinitive?
- Do all people converge to the same language?
- Do people learn language from every presentation? Is your teacher an enemy?
- Do people learn only from the sentences?
- Are there no biases at all?



Quoting Gold...

- “The input does not include reliable negative evidence, ... logical arguments suggest that in the absence of such evidence there must be strong innate constraints on the possible forms of grammar”.
- “(Gold) provided a logical proof which concluded that, without explicit error correction, the rules of a logical system with the structural complexity of a natural language grammar could not be inductively discovered, even in theory”.

Quoting Gold...

- “Gold (1967)... obtained results that implied that natural languages could not be learned only on the basis of positive evidence”
- “Gold showed that, for even simple classes of languages, no procedure (statistical or other) exists that could learn a language without non-trivial assumptions”
- “The problem is presented even more strikingly by Gold (1967) who, simulating language acquisition on a computer, argues that an unbiased learning who had to induce the rules of grammar from strings of input would require more than a human lifetime”
- Chomsky never quoted Gold...

Conclusion

- It does not seem that gold's proof shows domain-specificity, nor proves the APS
- Nevertheless, his paper had strong influence in the discussion due to some misuse of his learning model
- So... let's make good science...

Thanks!