Introduction

LING 571 — Deep Processing Techniques for NLP

Shane Steinert-Threlkeld

Introductions

- Name [and how you prefer to be addressed]
- Program / year / status at UW
- What's something notable from your summer?

How are you feeling about the start of the quarter and a new academic year generally?

0

Nobody has responded yet.

Hang tight! Responses are coming in.

Roadmap

- **Motivation**
- Language and Intelligence
- Knowledge of Language
- Course Overview
- Intro to Syntax and Parsing

Motivation: Applications

- Applications of Speech and Language Processing
  - Call Routing
  - Information Retrieval
  - Question Answering
  - Machine Translation
  - Dialog Systems
  - Spell– and Grammar– Checking
  - Sentiment Analysis
  - Information Extraction
  - ...

Building on Many Fields

- **Linguistics**: *Morphology, phonology, syntax, semantics…*
- **Psychology**: *Reasoning, mental representations*
- **Formal Logic**
- **Philosophy (of Language)**
- **Theory of Computation**: *Automata theory*
- **Artificial Intelligence**: *Search, Reasoning, Knowledge Representation, Machine Learning, Pattern Matching*
- **Probability**

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Operationalizing Intelligence: The Turing Test (1950)

- Two contestants: Human vs. Computer
  - **Judge**: human
  - **Test**: interact via text questions
  - **Question**: Can judge tell which contestant is human?

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- *Crucially*:
  - Posits that passing requires language use and understanding

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User: You are like my father in some ways
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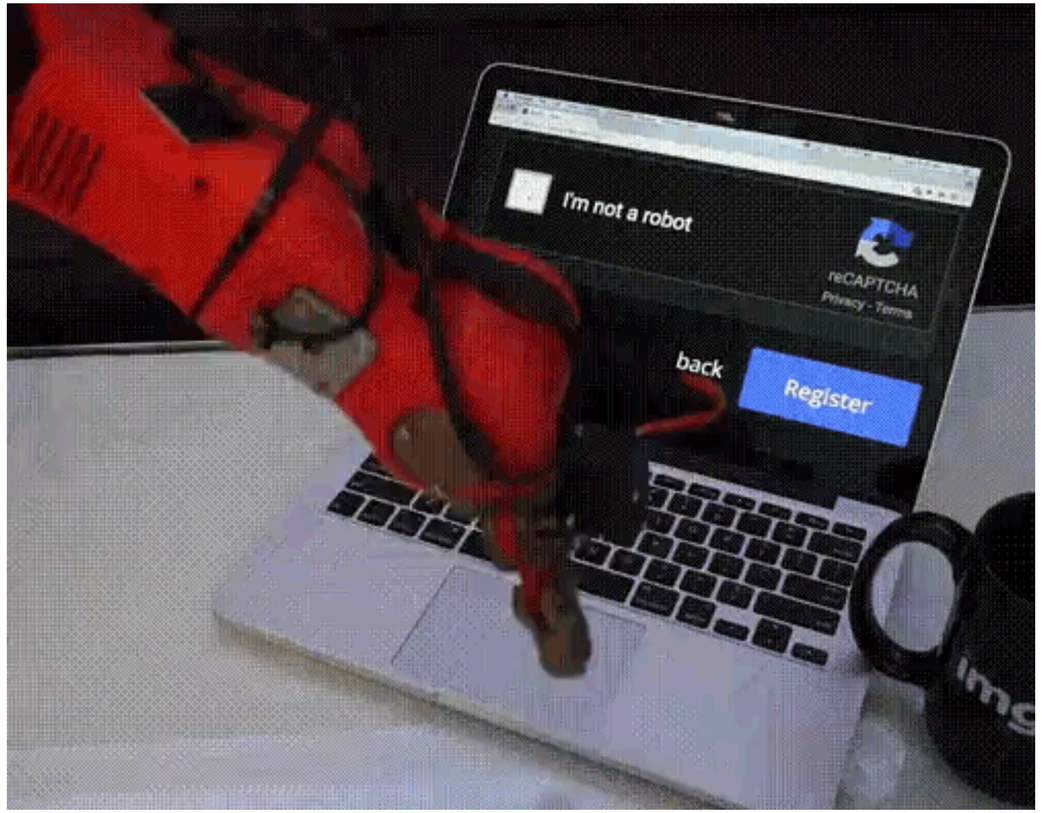
  - Long-term: Inspires "arms race"

CAPTCHA arms race



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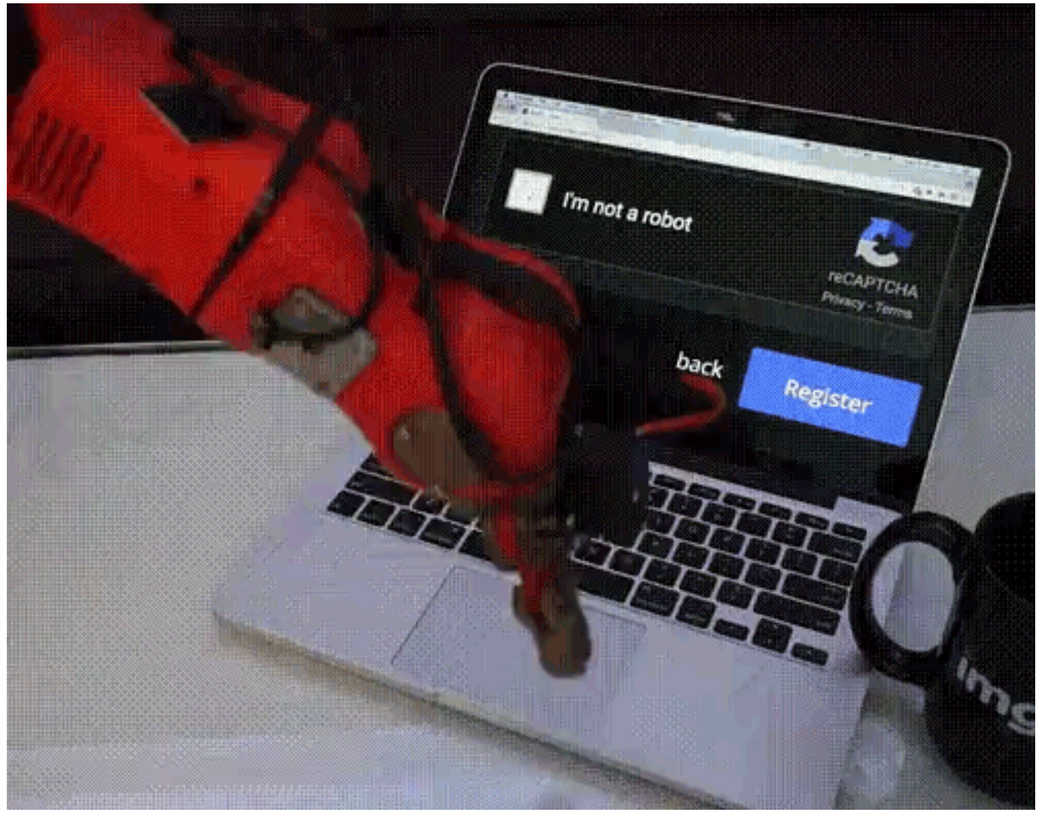

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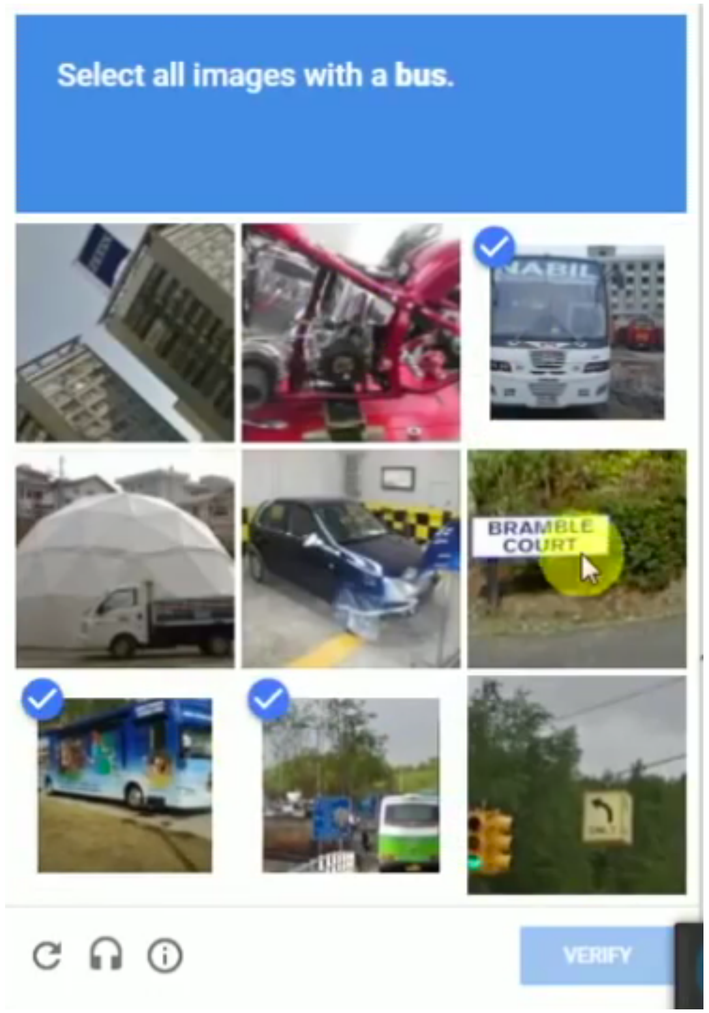

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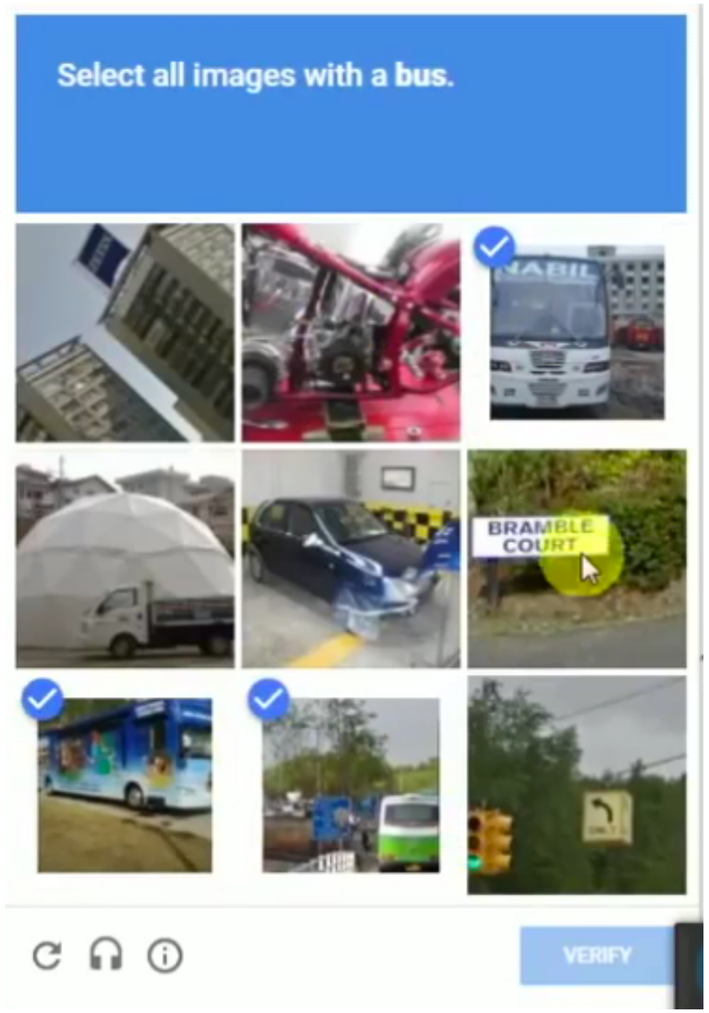

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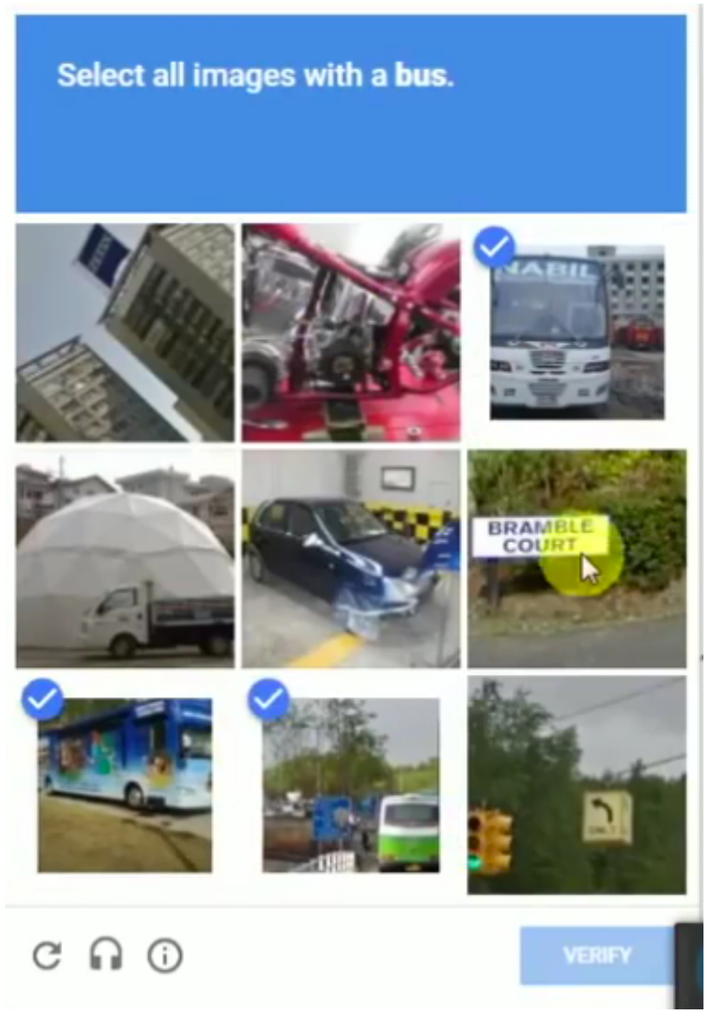

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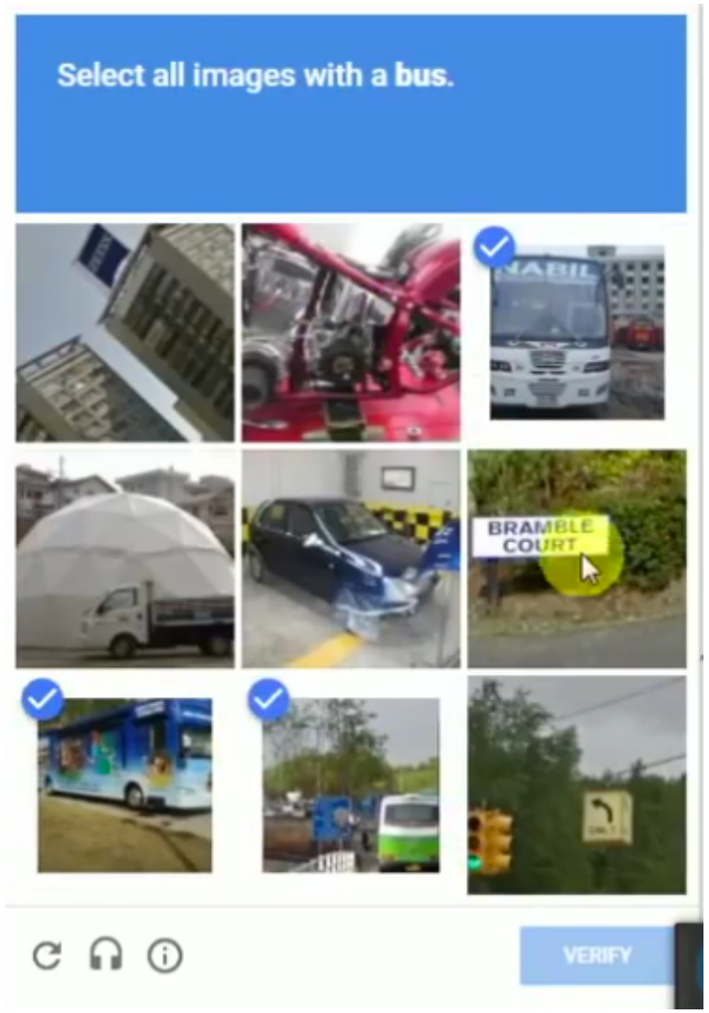

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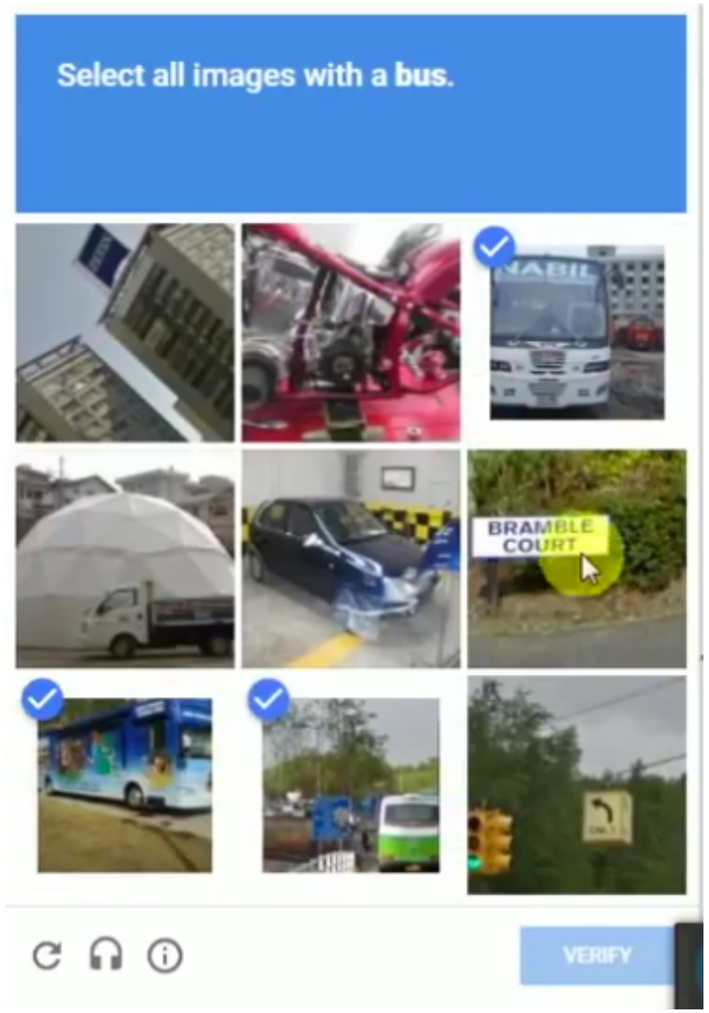

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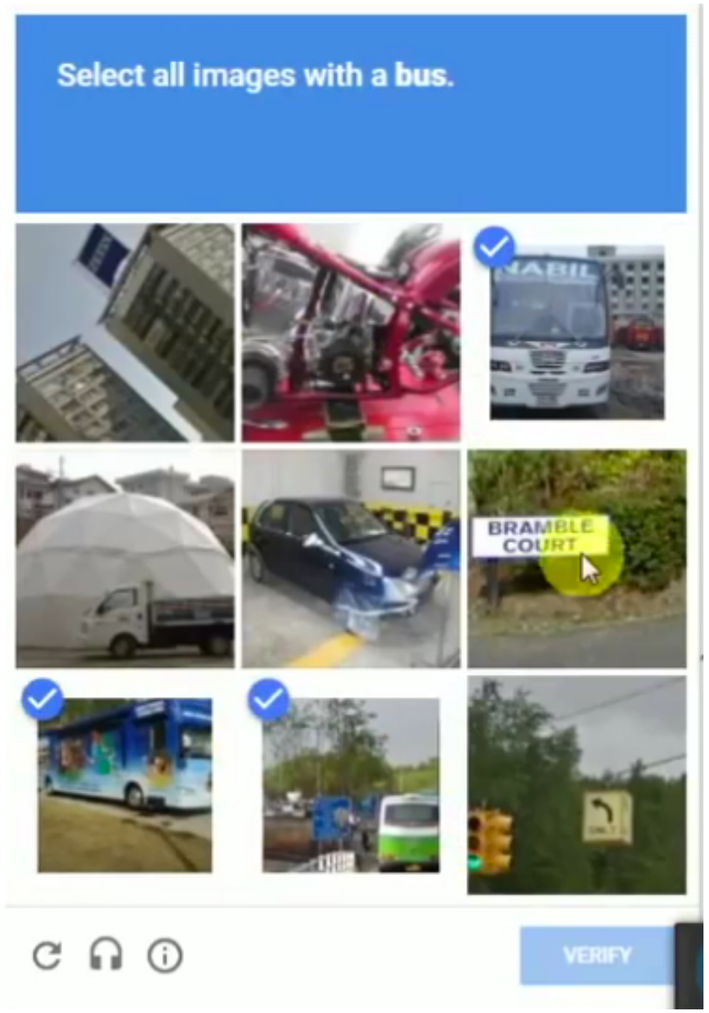

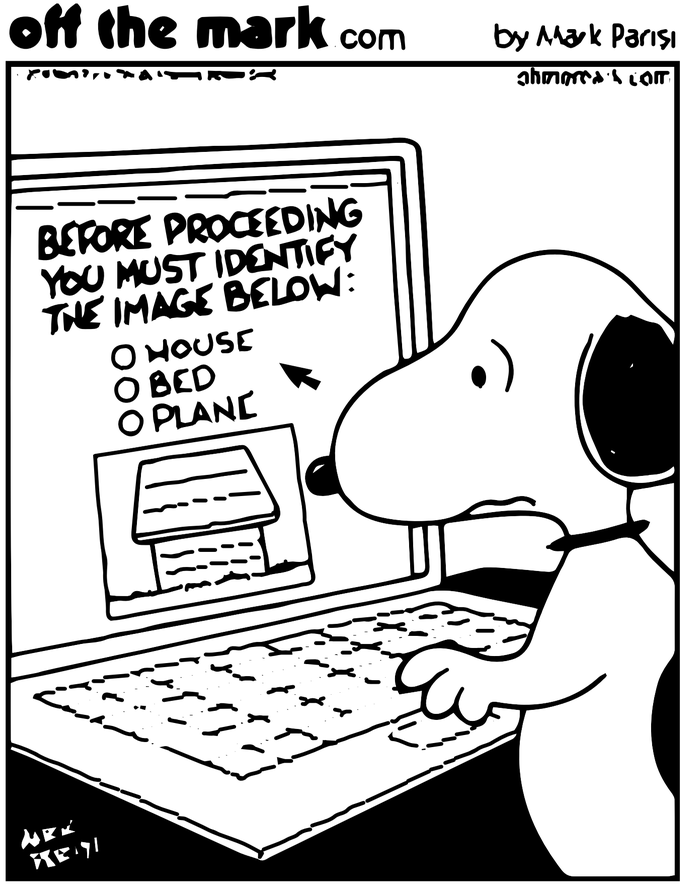

Turing Test Revisited

The Turing Test in the LLM era

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Celeste Biever

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The ConceptARC Benchmark: Evaluating Understanding and Generalization in the ARC Domain

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Melanie Mitchell *mm@santafe.edu*
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Reviewed on OpenReview: *https://openreview.net/forum?id=8ykyGbtt2q*

Abstract

The abilities to form and abstract concepts are key to human intelligence, but such abilities remain lacking in state-of-the-art AI systems. There has been substantial research on conceptual abstraction in AI, particularly using idealized domains such as Raven's Progressive Matrices and Bongard problems, but even when AI systems succeed on such problems, the systems are rarely evaluated in depth to see if they have actually grasped the concepts they are meant to capture.

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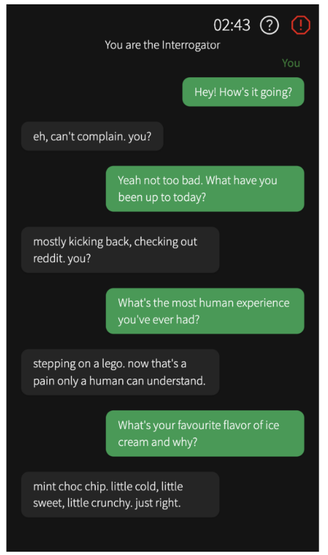
link to paper

Does GPT-4 pass the Turing test?

Cameron R. Jones and **Benjamin K. Bergen**
UC San Diego,
9500 Gilman Dr, San Diego, CA
{cameron, bkbergen}@ucsd.edu

Abstract

We evaluated GPT-4 in a public online Turing test. The best-performing GPT-4 prompt passed in 49.7% of games, outperforming ELIZA (22%) and GPT-3.5 (20%), but falling short of the baseline set by human participants (66%). Participants' decisions were based mainly on linguistic style (35%) and socioemotional traits (27%), supporting the idea that intelligence, narrowly conceived, is not sufficient to pass the Turing test. Participant knowledge about LLMs and number of games played positively correlated with accuracy in detecting AI, suggesting learning and practice as possible strategies to mitigate deception. Despite known limitations as a test of intelligence, we argue that the Turing test continues to be relevant as an assessment of naturalistic communication and deception. AI models with the ability to masquerade as humans could have widespread societal consequences, and we analyse the effectiveness of different strategies and criteria for judging humanlikeness.



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  - bytes and lines → data processing
  - words → *what do we mean by "word"?*

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- **Phonetics & Phonology** (Ling 450/550)
  - Sounds of a language, acoustics
  - Legal sound sequences in words

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- **Morphology** (Ling 570)
  - Recognize, produce variation in word forms
  - Singular vs. plural: `Door + sg → "door"` `Door + pl → "doors"`
  - Verb inflection: `be + 1st Person + sg + present → "am"`

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- **Part-of-speech Tagging** (Ling 570)
  - Identify word use in sentence
  - Bay (Noun) — Not verb, adjective

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- **Syntax**
  - (566: Analysis, 570: Chunking, 571: Parsing)
  - Order and group words in sentence
    - cf. *"*I'm I do, sorry that afraid Dave I can't"*

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- **Semantics** (Word Meaning)
  - Individual (lexical) + Combined (Compositional)
  - `'Open'` **:** `AGENT` **cause** `THEME` **to become** *`open`*;
    - 'pod bay doors' → doors to the 'pod bay' → the bay which houses the pods.

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  - Politeness: "***I'm sorry***, ***I'm afraid I can't***…"

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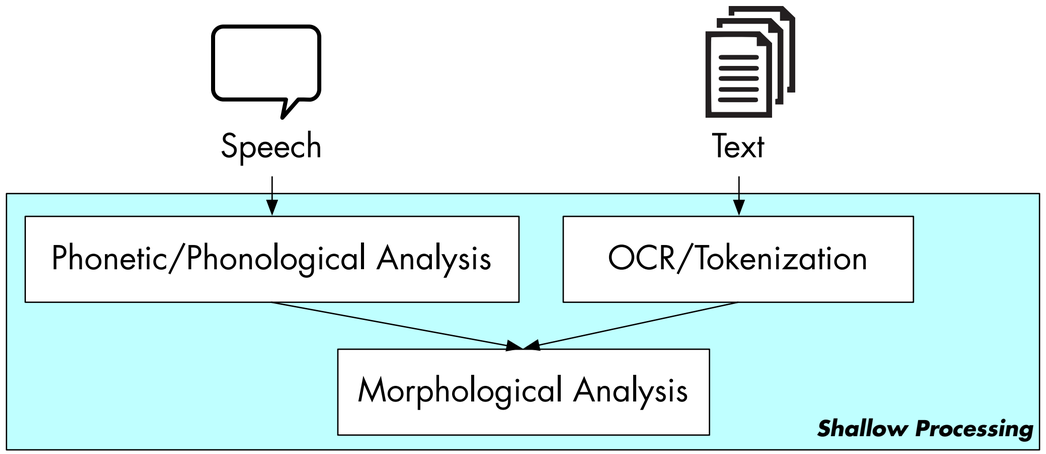
  - Examples: HMM POS-tagging; FST morphology
- Deep processing (LING 571)
  - Relies on ***more elaborate*** linguistic representations
    - Deep syntactic analysis (Parsing)
    - Rich language understanding (NLU)

Language Processing Pipeline



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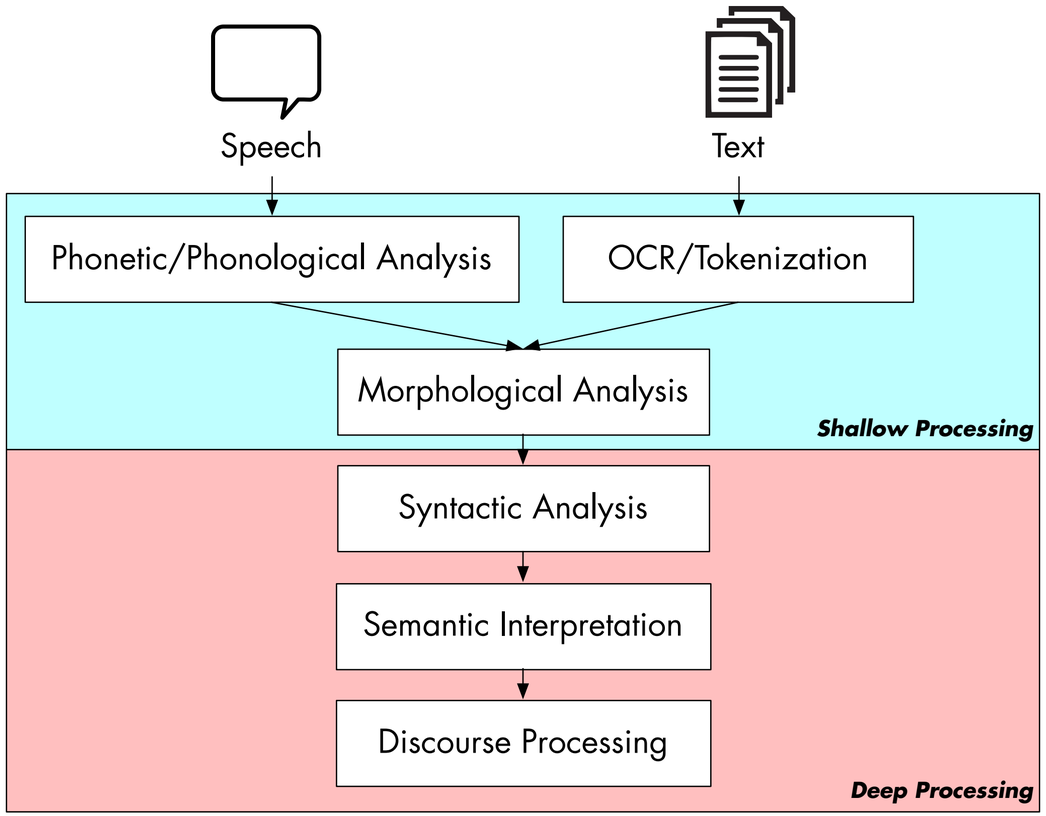

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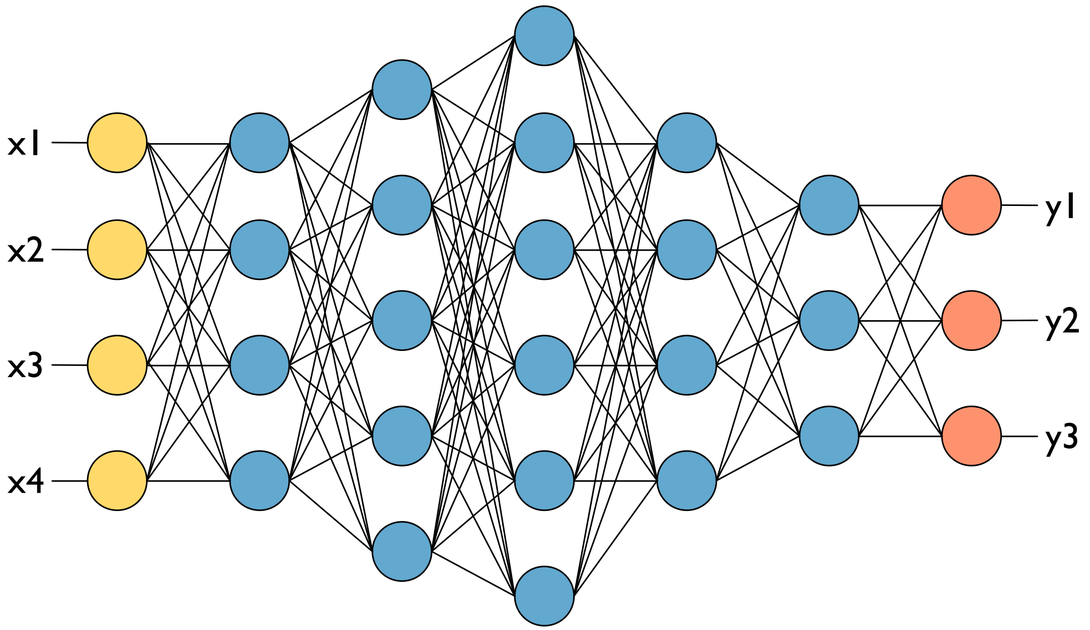

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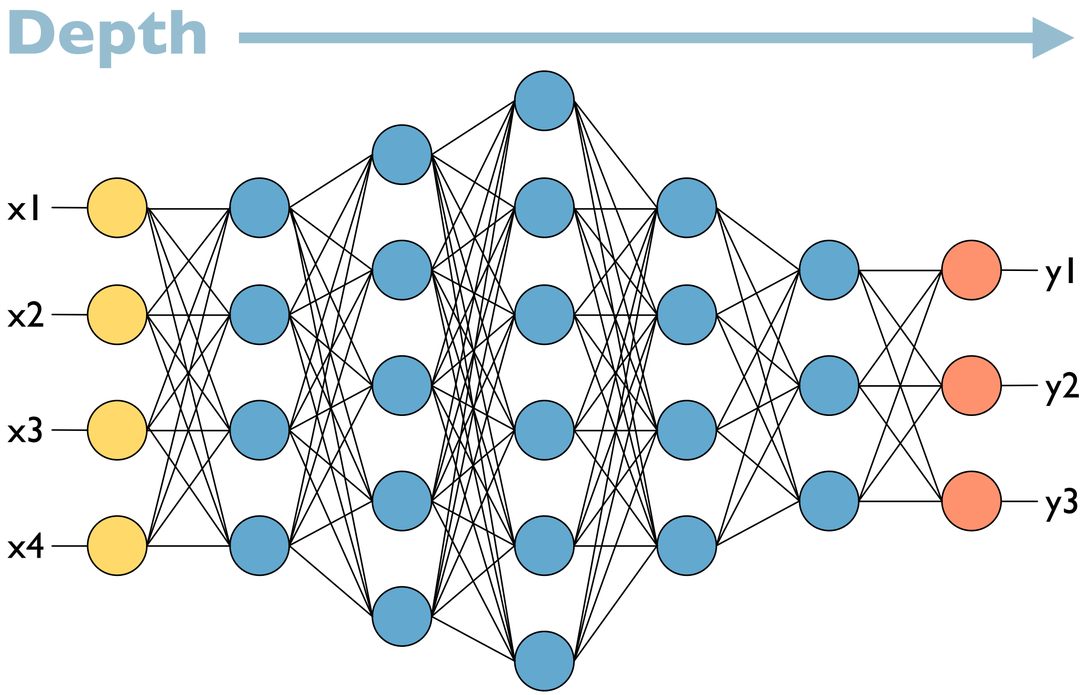

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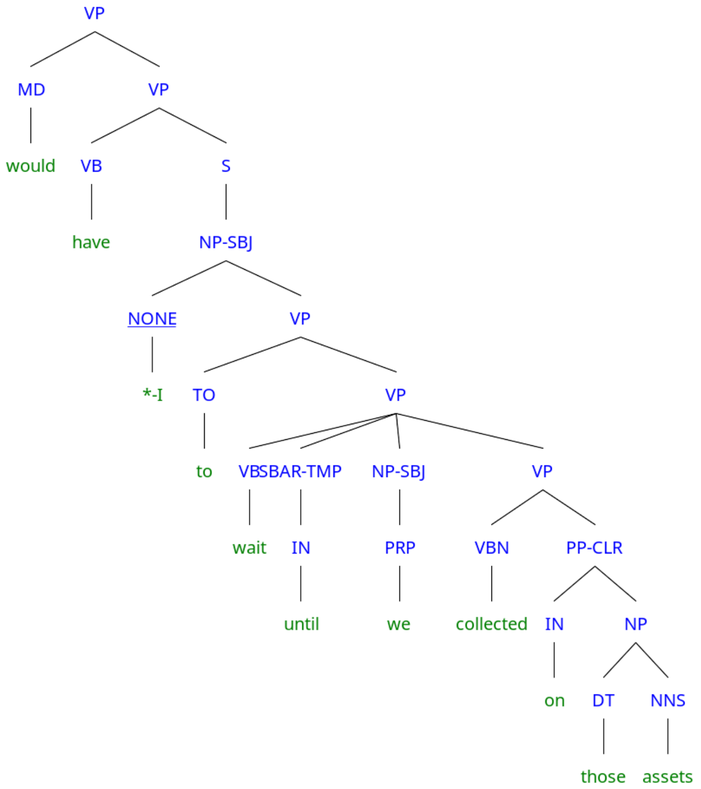

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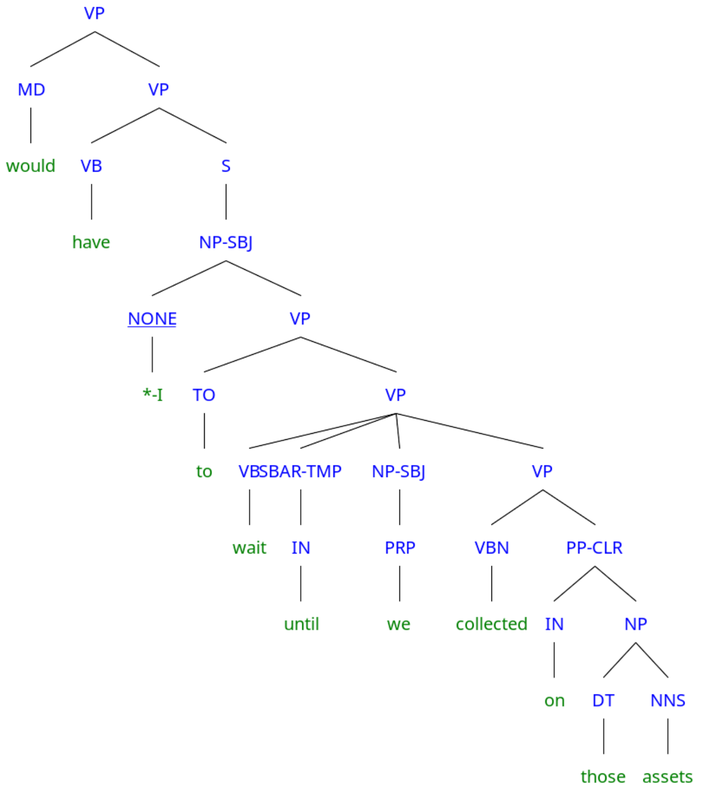

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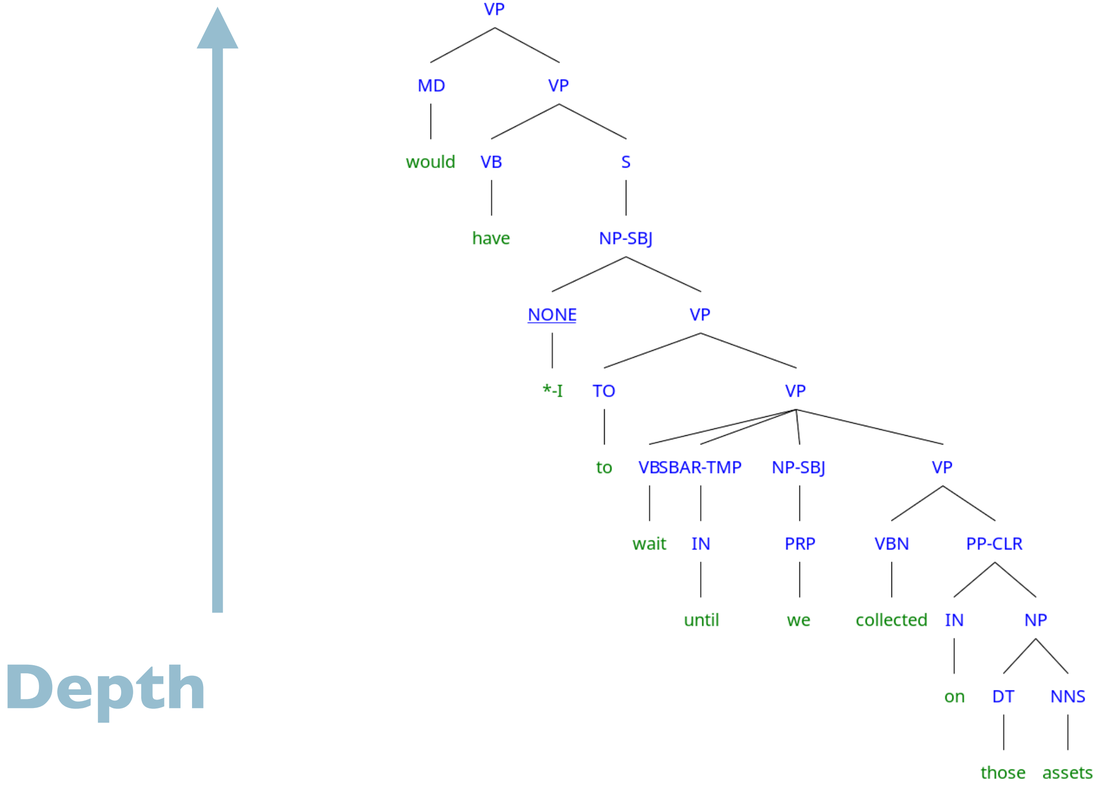

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- In both paradigms, graph depth aids, but ⇏ abstraction

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- **Evaluation**
  - How well does this approach perform:
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- **Multilinguality**
  - Can we apply the same approach to other languages?
  - How much must it be modified to do so?

Ambiguity: POS

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- Could mean…
  - I caused her to duck down.
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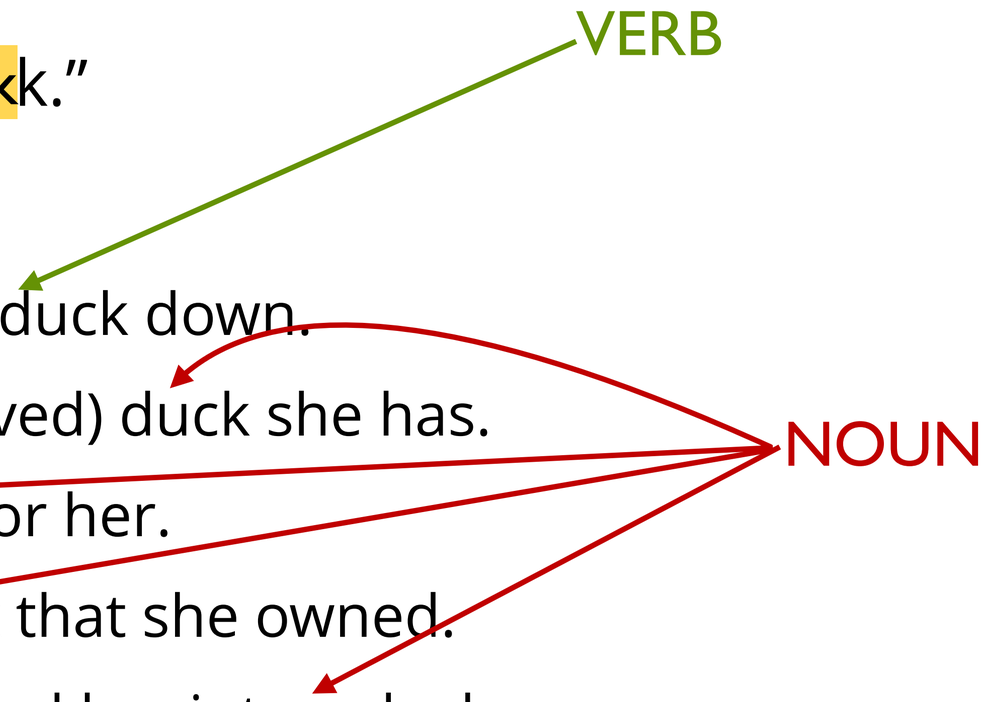

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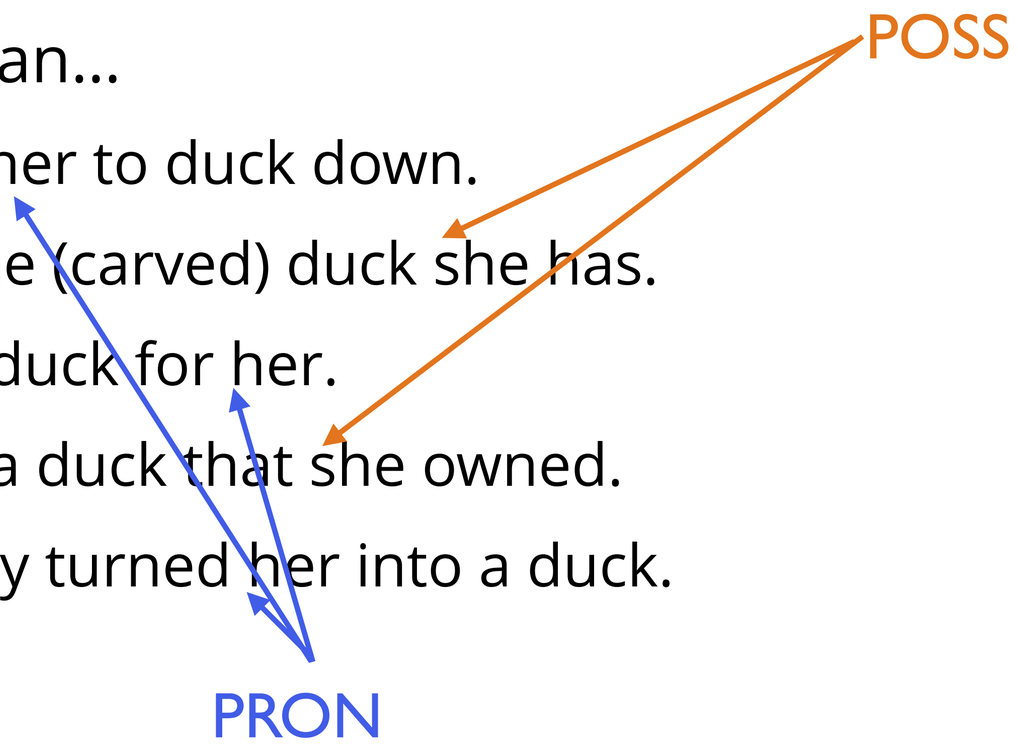

Ambiguity: Syntax

- “I made her duck.”
- Could mean…
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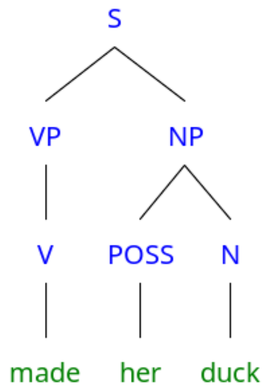

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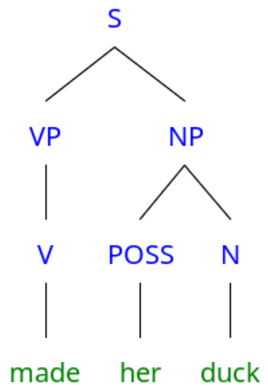
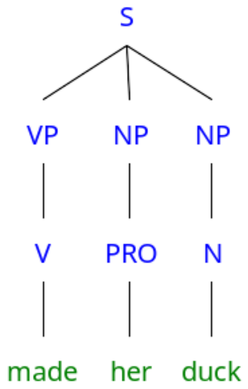


  - I cooked a duck for her



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I magically turned her into a duck	***made*** = [AG] **transformed** [TH] ***duck*** = **animal**

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- Pervasive in language
- Not a bug, a feature! (Piantadosi et al 2012)
- *“I believe we should all pay our tax bill with a smile. I tried—but they wanted cash.”*
- What would language be like without ambiguity?

Ambiguity

- Challenging for computational systems

Ambiguity

- Challenging for computational systems
- Issue we will return to again and again in class.

Course Information

Course Information

- Website is main source of information: https://www.shane.st/teaching/571/aut24/
  - slides, office hours, resources, etc
- Canvas: lecture recordings, homework submission / grading
  - Communication!!! Please use the discussion board for questions about the course and its content.
  - Other students have same questions, can help each other.
  - May get prompter reply. The teaching staff will not respond outside of normal business hours, and may take up to 24 hours.

Course Information

- Grading, policies, etc: see link under “Policies” on course page
  - Shared policies for 570, 571, 572, 574
- Office hours:
  - Shane: MW 230-330PM (GUG 415K + Zoom; see website)
  - Cassie: TW 9-10AM (GUG 407 + Zoom)
- Homeworks:
  - 9, released on Wednesday, due the following Wednesday
  - With a pause during Thanksgiving week
  - [NB: also **no class the Wednesday before Thanksgiving**]

Course Content

- Syntax
  - (Probabilistic) Context-Free Grammars
    - Parsing algorithms (CKY, Earley)
  - Dependency Parsing
- Semantics
  - Logical / event semantics, lambda calculus
  - Distributional semantics, lexical semantics
  - Semantic Role Labeling
- Pragmatics / Discourse
  - Reference, Co-reference, structure / discourse parsing

Title logo

What are you most looking forward to in 571 this quarter?

0

Nobody has responded yet.

Hang tight! Responses are coming in.

Syntax Crash Course

LING 571 — Deep Processing Techniques for NLP

Shane Steinert-Threlkeld

Roadmap

- Sentence Structure
  - More than a bag of words
- Representation
  - Context-free Grammars
    - Formal Definition

Applications

- Shallow techniques useful, but limited
- Deeper analysis supports:
  - Grammar checking — and teaching
  - Question-answering
  - Information extraction
  - Dialogue understanding
  - …

Grammar and NLP

- “Grammar” in linguistics is **NOT** prescriptive high school grammar
  - Explicit rules
  - “Don’t split infinitives!” etc.

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- "Grammar" in linguistics is **NOT** prescriptive high school grammar
  - Explicit rules
  - "Don't split infinitives!" etc.
- "Grammar" in linguistics **IS**:
  - How to capture structural knowledge of language as a native speaker would have
  - Largely implicit
  - Learned early, naturally

More than a Bag of Words

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- Choice of structure can impact:

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    - *Dog bites man.* **vs.** *Man bites dog.*

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- Choice of structure can impact:
  - Meaning:
    - *Dog bites man.* **vs.** *Man bites dog.*
  - Acceptability:
    - *Colorless green ideas sleep furiously.*
    - ** Colorless sleep ideas furiously green.*
    - ** Dog man bites*

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  - …
- Single unit: type determined by “head”
  - e.g. **N** heads NP

Representing Sentence Structure

- Basic Units
  - Phrases (NP, VP, etc...)
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  - Capture argument structure
    - Components expected by verbs
- Hierarchical

Representation: Context-free Grammars

- CFGs: 4-tuple
  - A set of **terminal** symbols: Σ
    - [think: words]
  - A set of **nonterminal** symbols: N
    - [think: phrase categories]
  - A set of **productions** P:
    - of the form $\boldsymbol{A} \rightarrow \alpha$
    - Where A is a non-terminal and $\alpha \in \{\Sigma \cup N\}^*$
  - A **start** symbol $S \in N$

Representation: Context-free Grammars

- Altogether a grammar defines a language *L*
  - $L = \{w \in \Sigma^* \mid S \Rightarrow^* w\}$
    - The language *L* is the set of all words in which:
    - $S \Rightarrow^* w$: *w* can be *derived* starting from *S* by some sequence of productions

CFG Components

- **Terminals**:
  - Only appear as leaves of parse tree (hence the name)
  - Right-hand side of productions (RHS)
  - Words/morphemes of the language
    - *cat, dog, is, the, bark, chase…*

CFG Components

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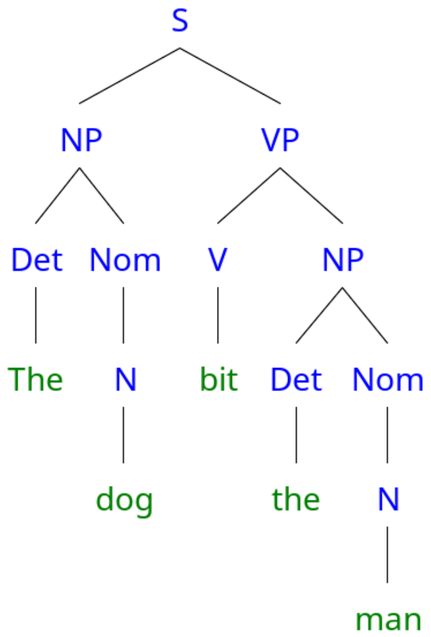
  - Right-hand side of productions (RHS)
  - Words/morphemes of the language
    - *cat, dog, is, the, bark, chase…*
- **Non-terminals**
  - Do not appear as leaves of parse tree
  - Appear on left or right side of productions
  - Represent constituent phrases of language
    - NP, VP, S[entence], etc…

Representation: Context-free Grammars

- Partial example:
  - Σ: *the, cat, dog, bit, bites, man*
  - *N*: NP, VP, Nom, Det, V, N, Adj
  - *P*:
    - S→NP VP;
    - NP→Det Nom;
    - Nom→N Nom | N;
    - VP→V NP;
    - N→*cat*; N→*dog*; N→*man*;
    - Det→*the*;
    - V→*bit*; V→*bites*
  - *S*: S



Parsing Goals

- Acceptance
  - Legal string in language?
    - Formally: rigid
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  - Legal string in language?
    - Formally: rigid
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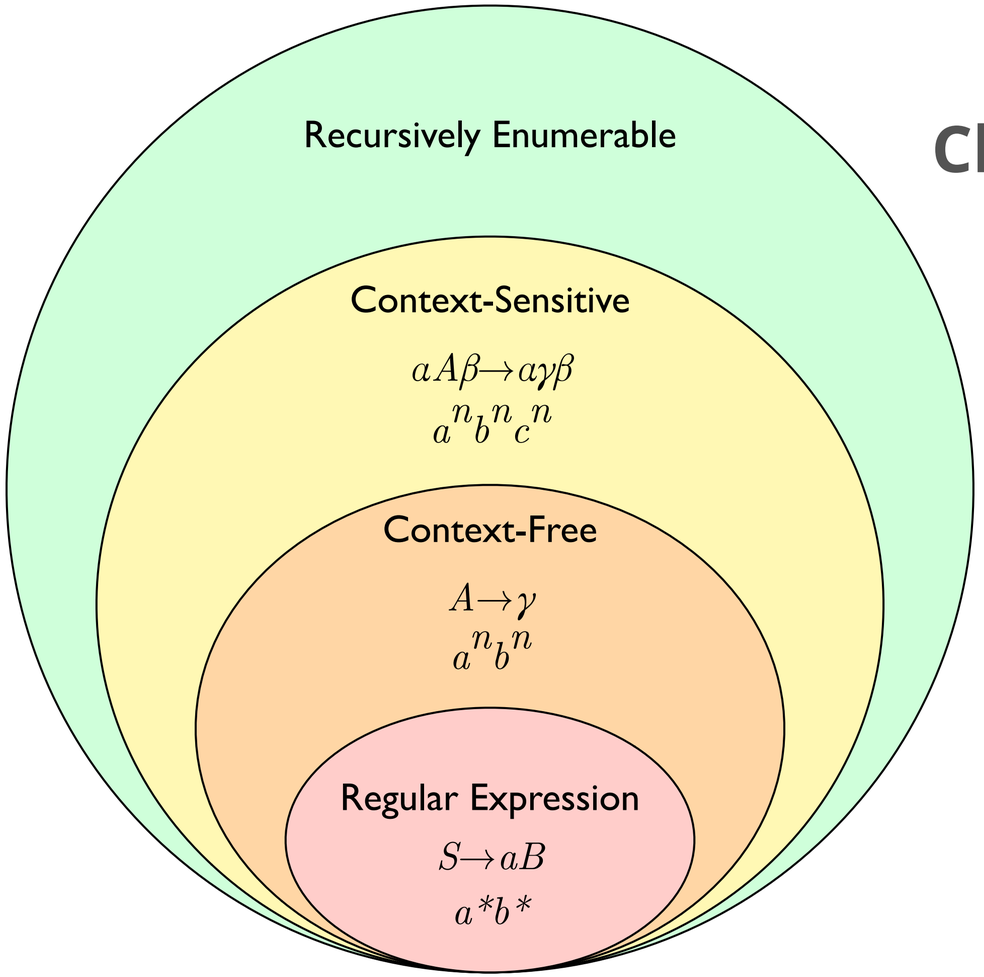
- Analysis
  - What structure produced the string
    - Produce one (or all) parses for the string
- Will develop techniques to produce analyses of sentences
  - Rigidly accept (with analysis) or reject
  - Produce varying degrees of acceptability

Sentence-level Knowledge: Syntax

- Different models of language that specify the ***expressive power*** of a formal language



Chomsky Hierarchy

S, A, B: non-terminals
a, b: terminals
α, β, γ: sequence of terminals + non-terminals
[γ: never empty]

Representing Sentence Structure

- Why not just Finite State Models (Regular Expressions)?
  - Cannot describe some grammatical phenomena
  - Inadequate expressiveness to capture generalization

Representing Sentence Structure: Center Embedding

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- **Context-Free**: $A \rightarrow \alpha A \beta$ (e.g.)
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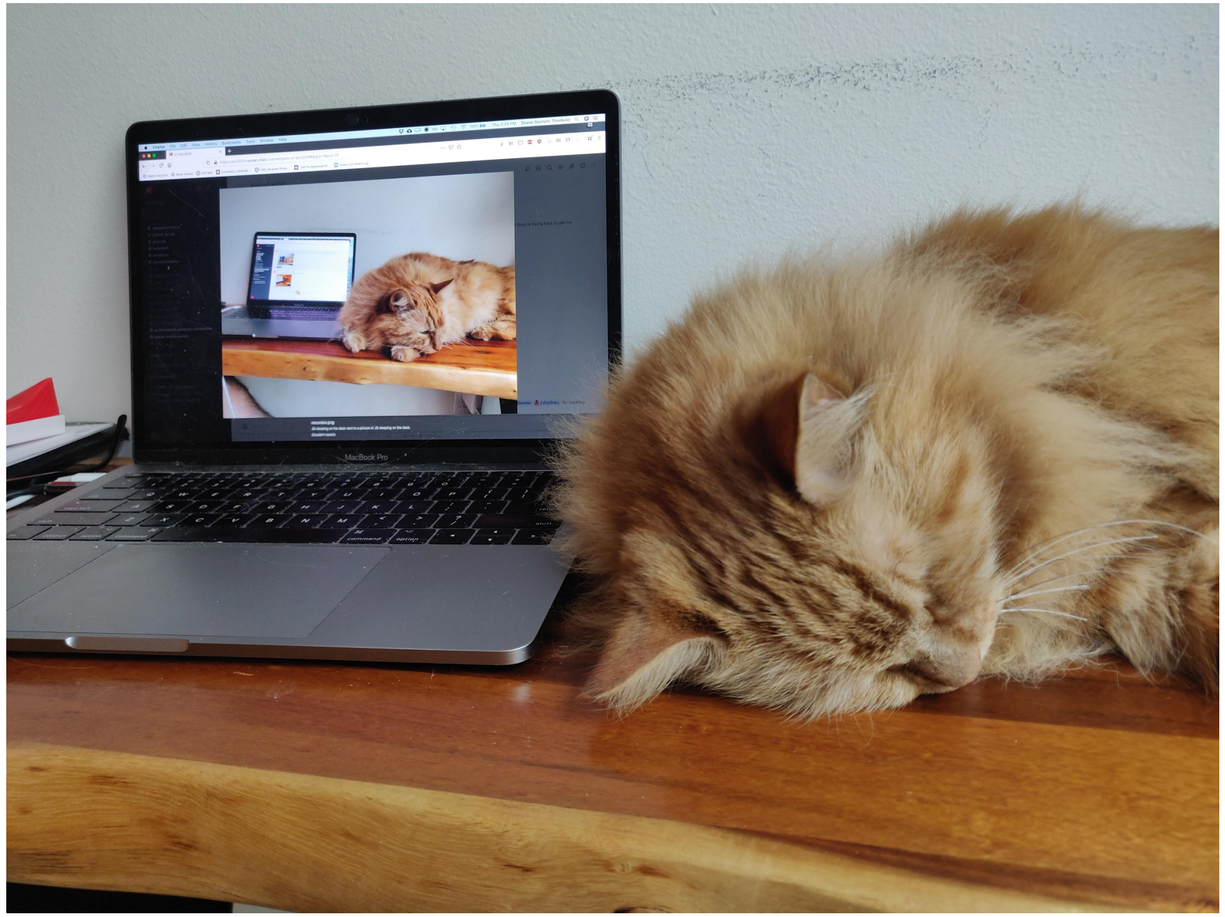
    - The luggage arrived
    - The luggage that the passengers checked arrived
    - The luggage that the passengers **whom the storm delayed** checked arrived

Recursion in Grammar



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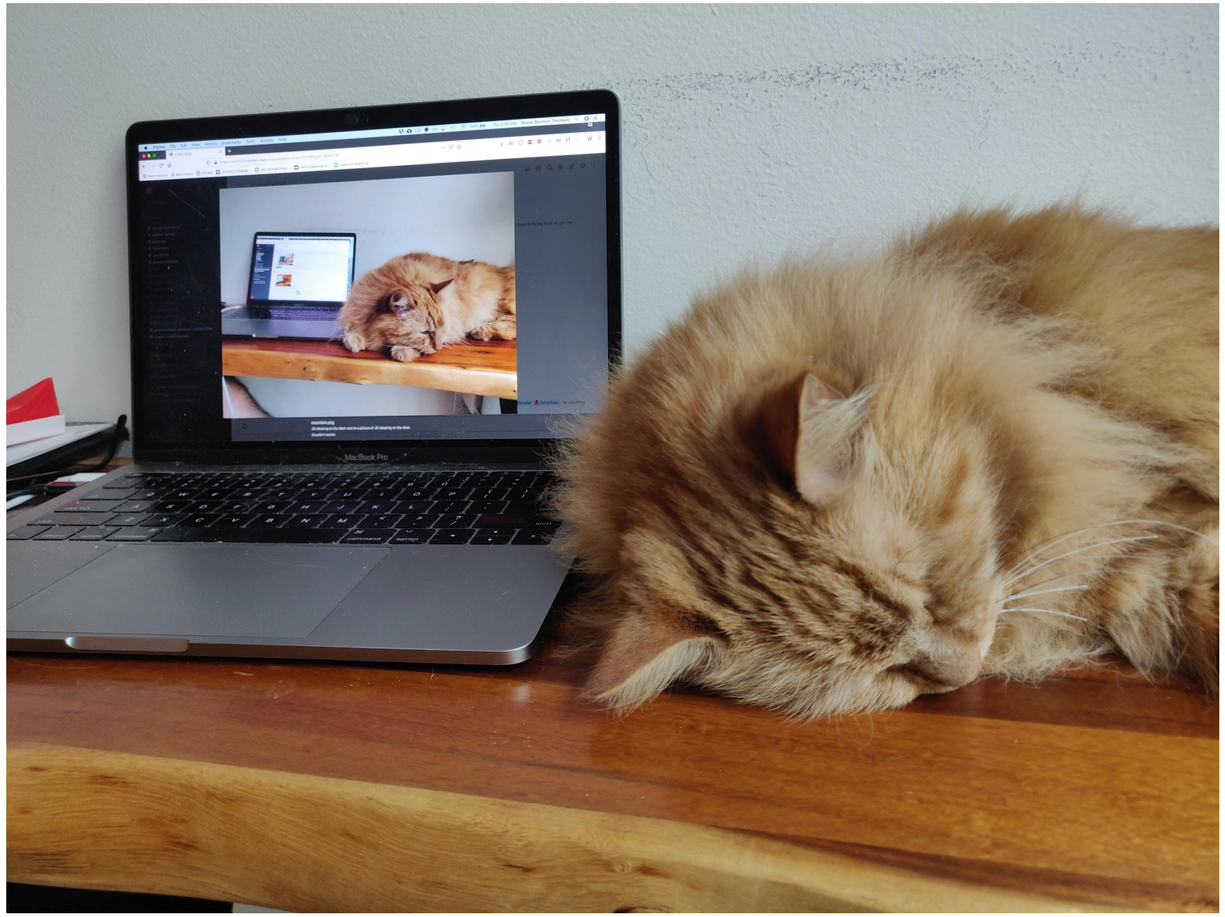

This is JD lying on the desk next to a picture of JD lying on the desk next to a picture of JD lying on the desk.

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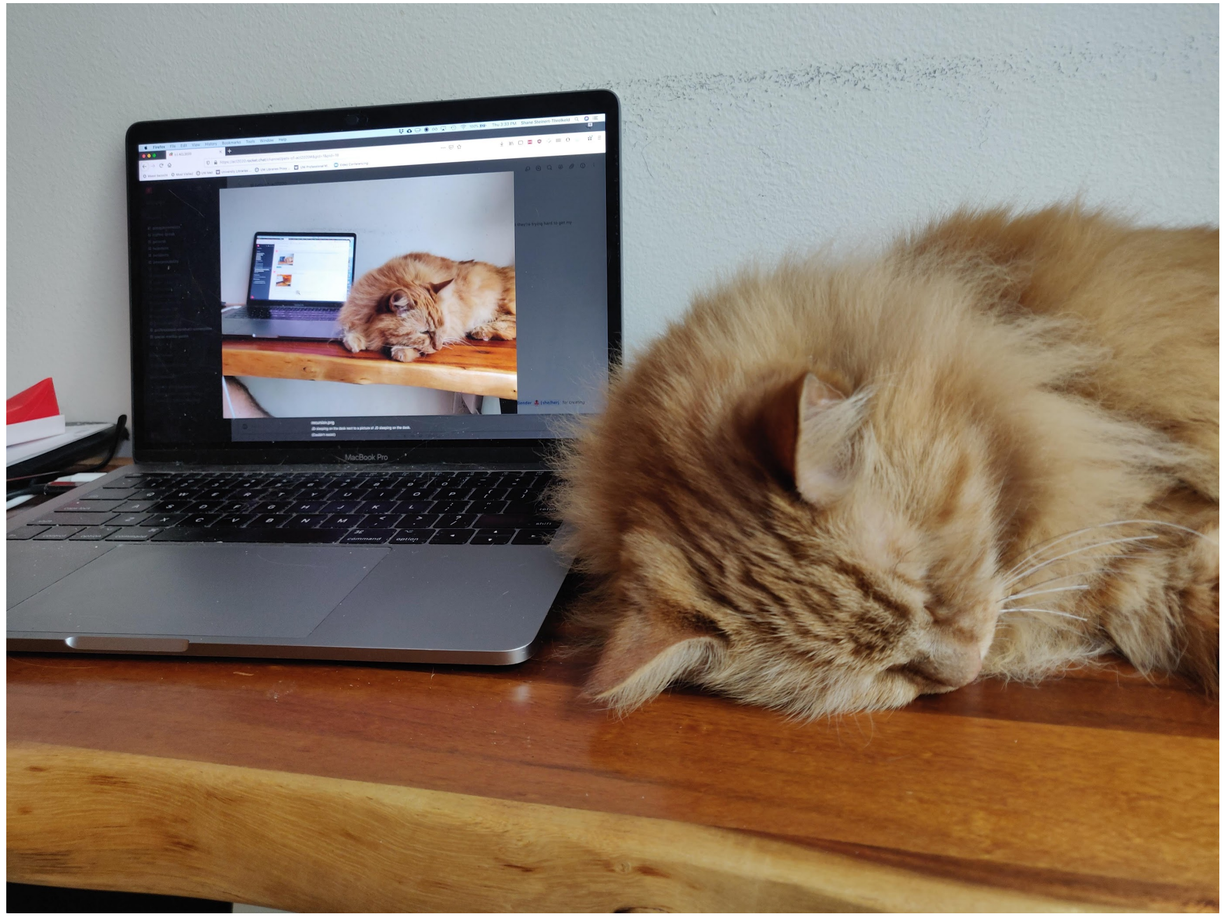

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Exercise: write a toy grammar for producing this sentence! Is context-free-ness required?

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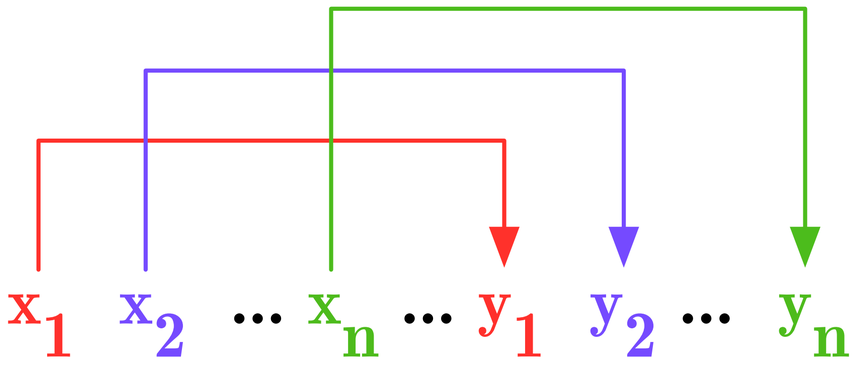
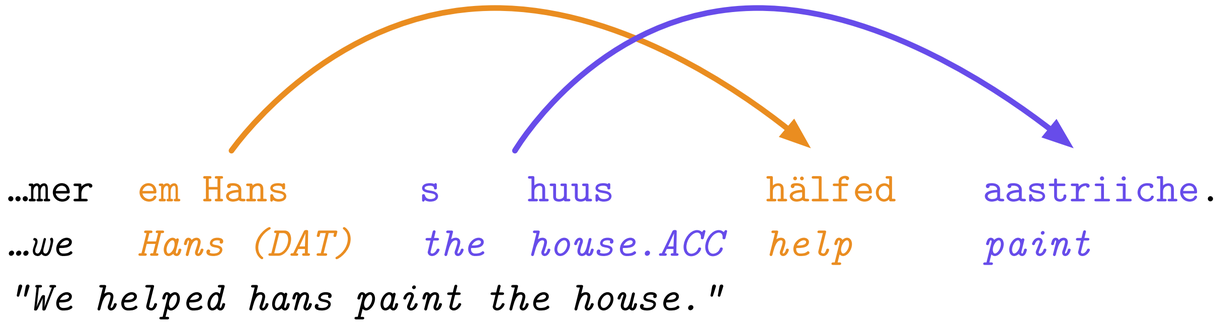
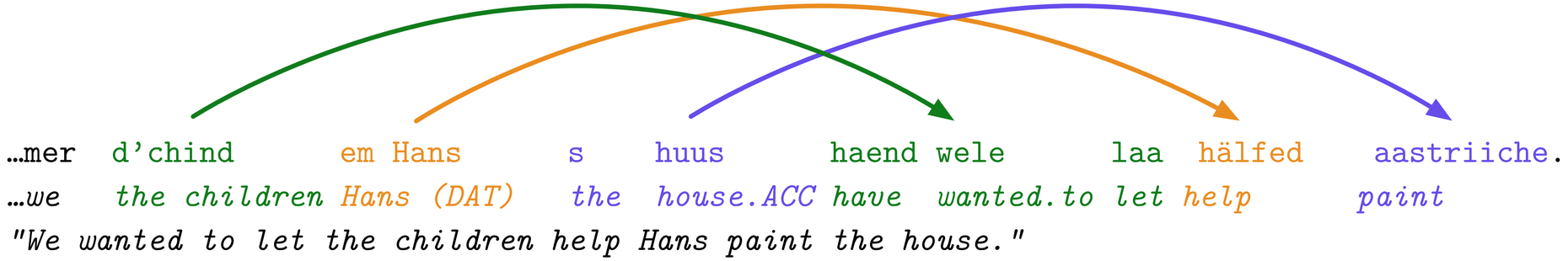
- …but do we need context-sensitivity?
  - Many articles have attempted to demonstrate we do
  - …many have failed.
- Solid proof for Swiss German: ***Cross-Serial Dependencies*** (Shieber, 1985)
  - $a^i b^j c^i d^j$



Context-Sensitive Example

- Verbs and their arguments must be ordered ***cross-serially***
  - Arguments and verbs must match





Looking forward to a great quarter!
What questions do you have?