

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?



Title logo

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



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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 - **Question**: Can judge tell which contestant is human?
- **Crucially**:
 - Posits that passing requires language use and understanding

Limitations of the Turing Test

- ELIZA ([Weizenbaum, 1966](#)) [[Try it Online](#)]

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User: You are like my father in some ways

ELIZA: WHAT RESEMBLANCE DO YOU SEE

USER: You are not very aggressive

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- Simple pattern matching technique

Turing Test Revisited:

“On the web, no one knows you’re a...”

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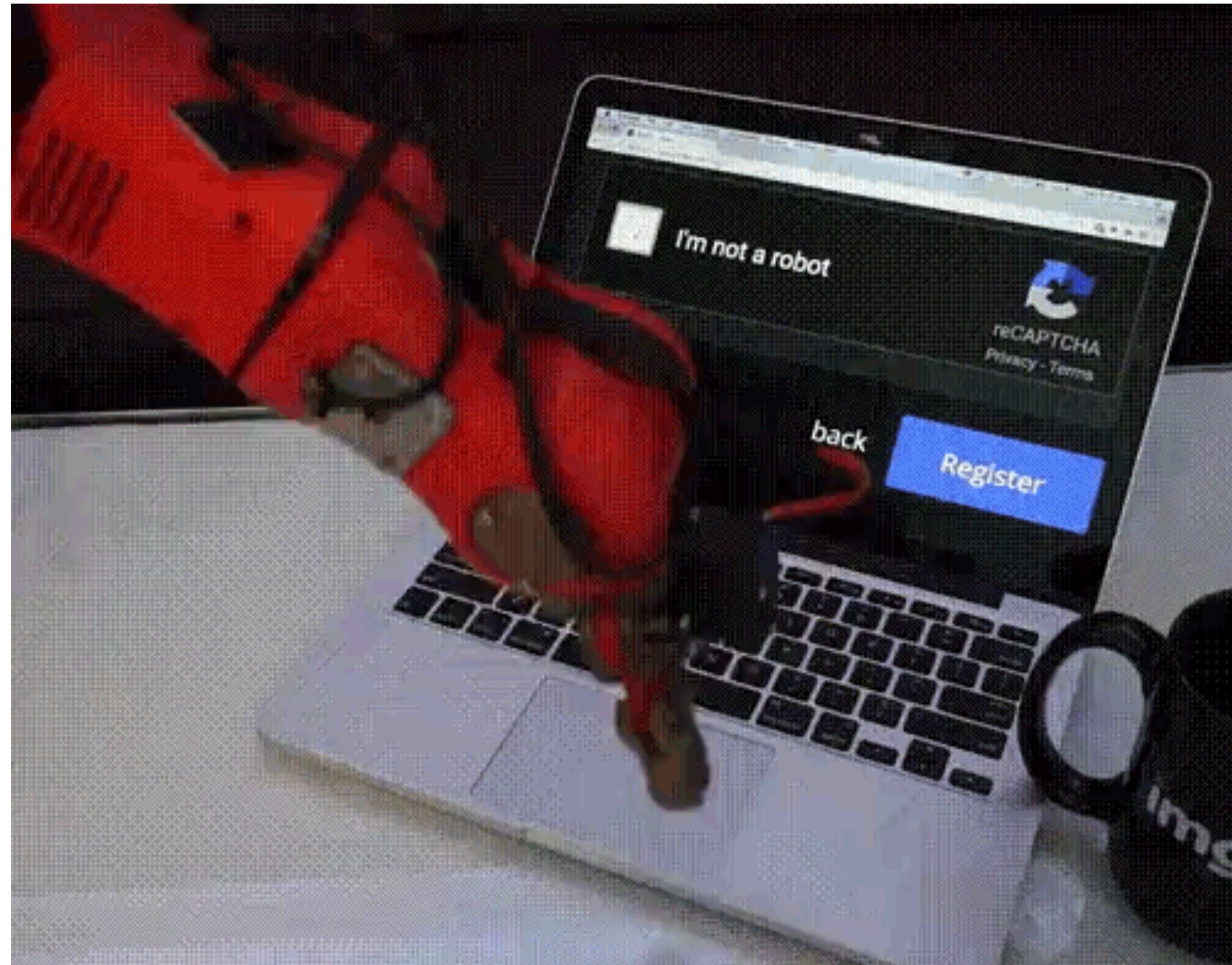
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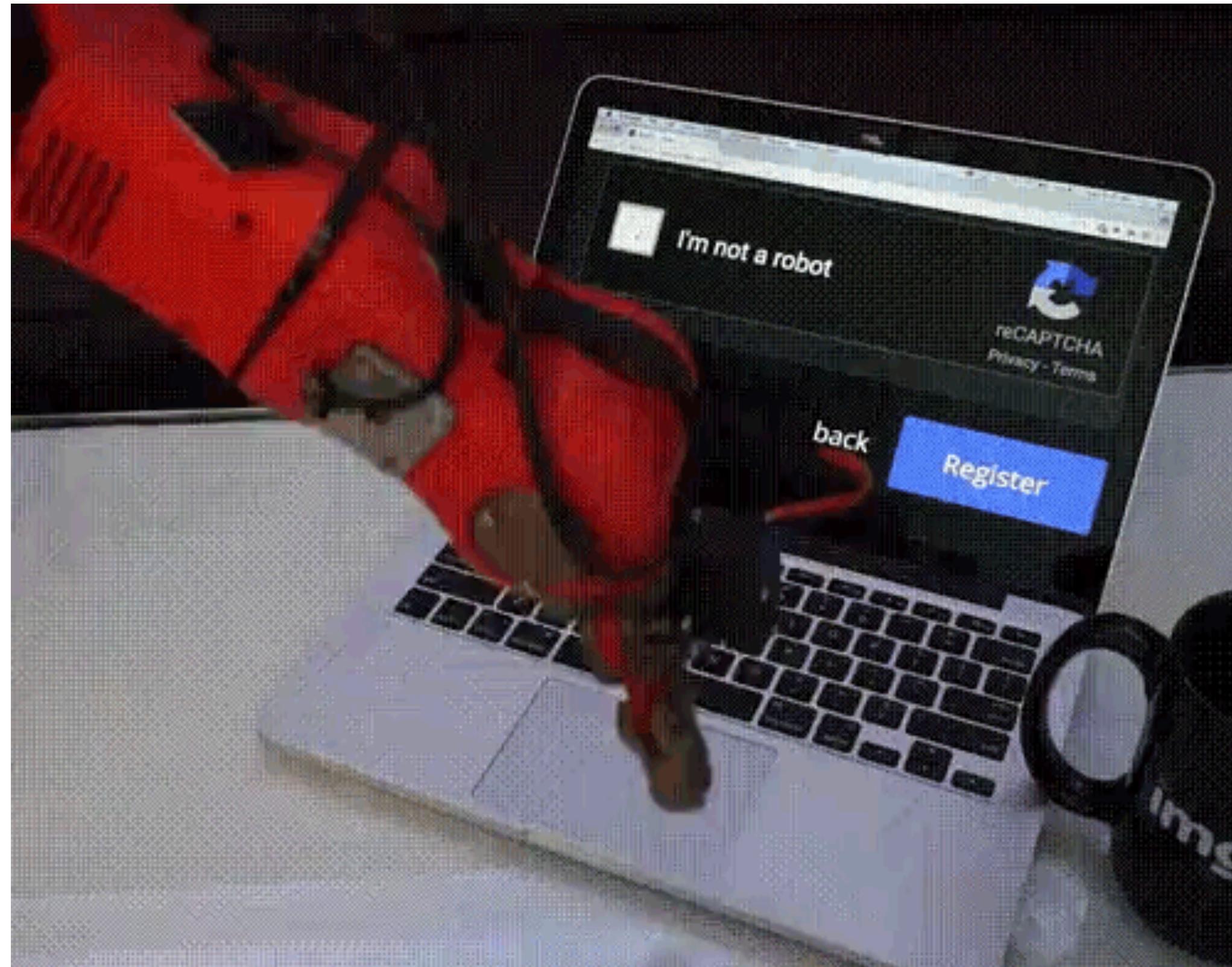
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 - Long-term: Inspires “arms race”

CAPTCHA arms race



CAPTCHA arms race



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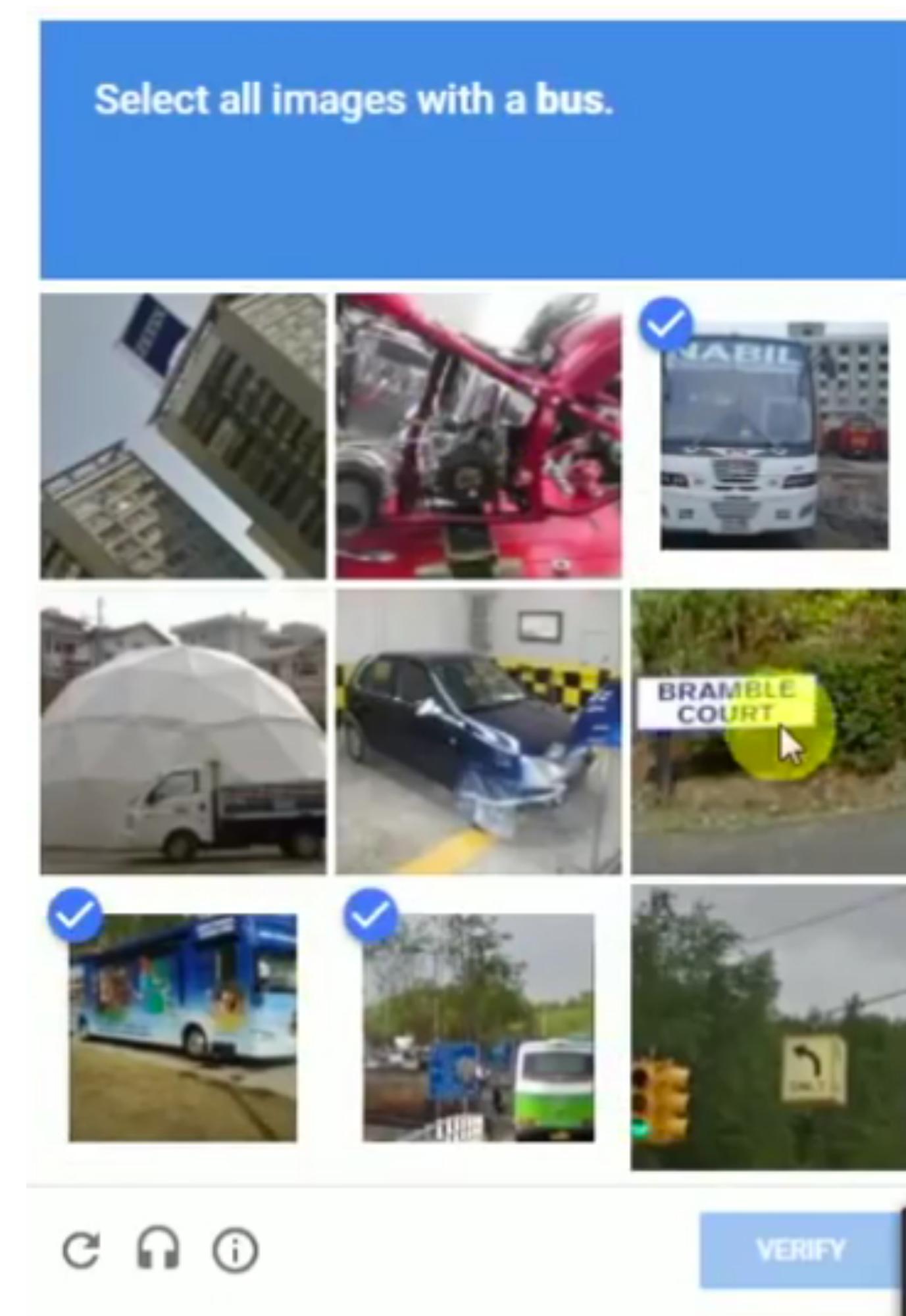
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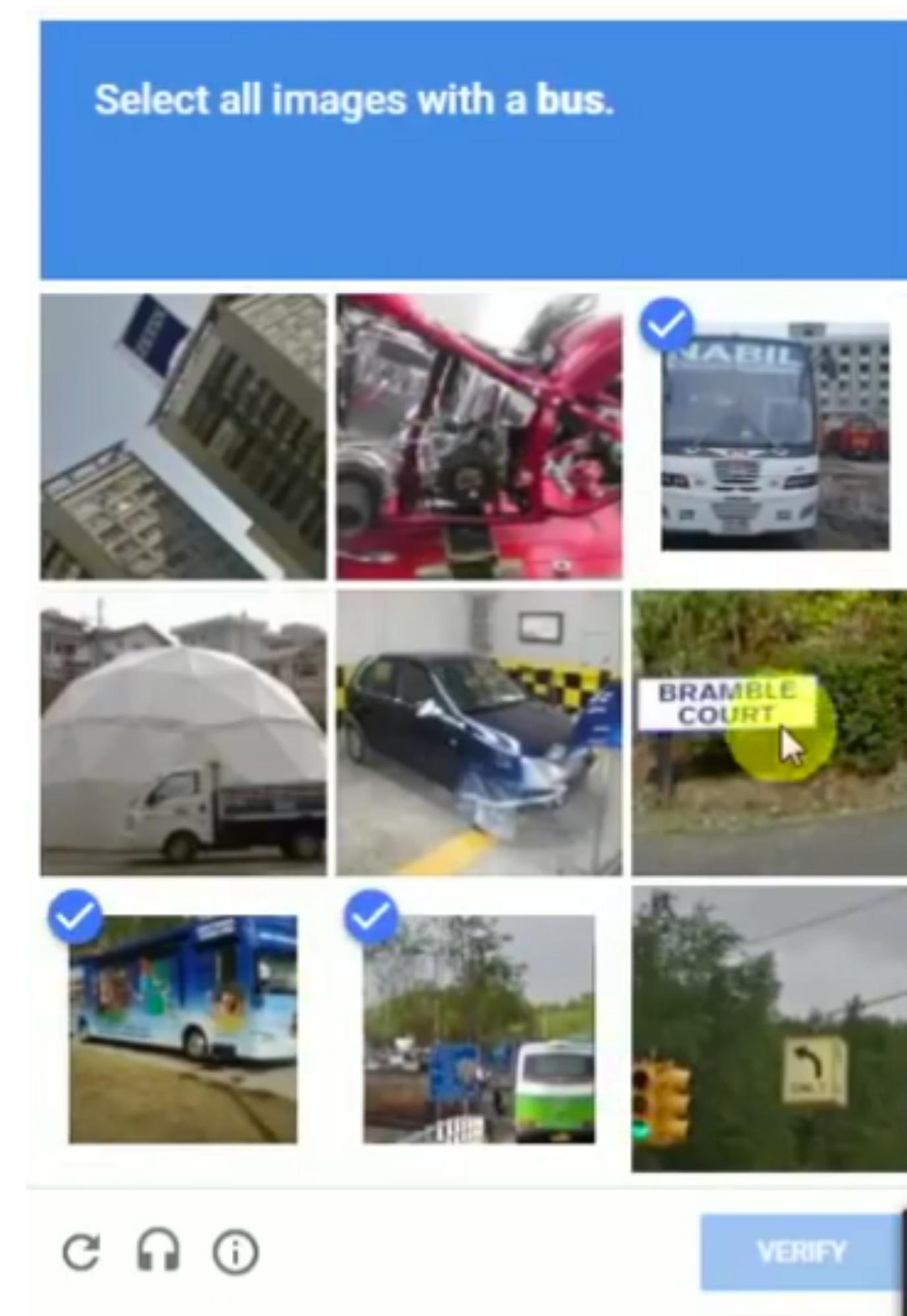
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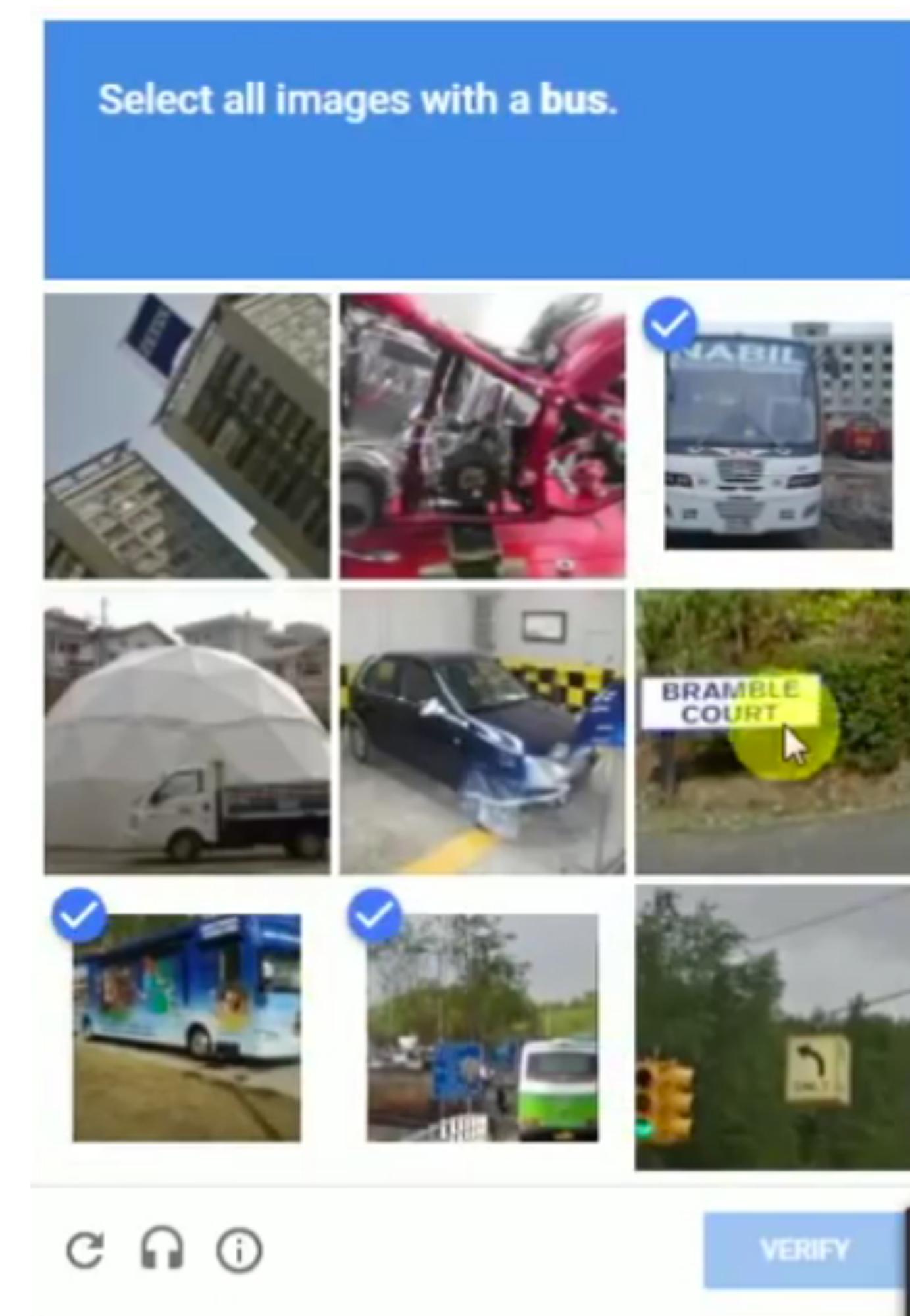
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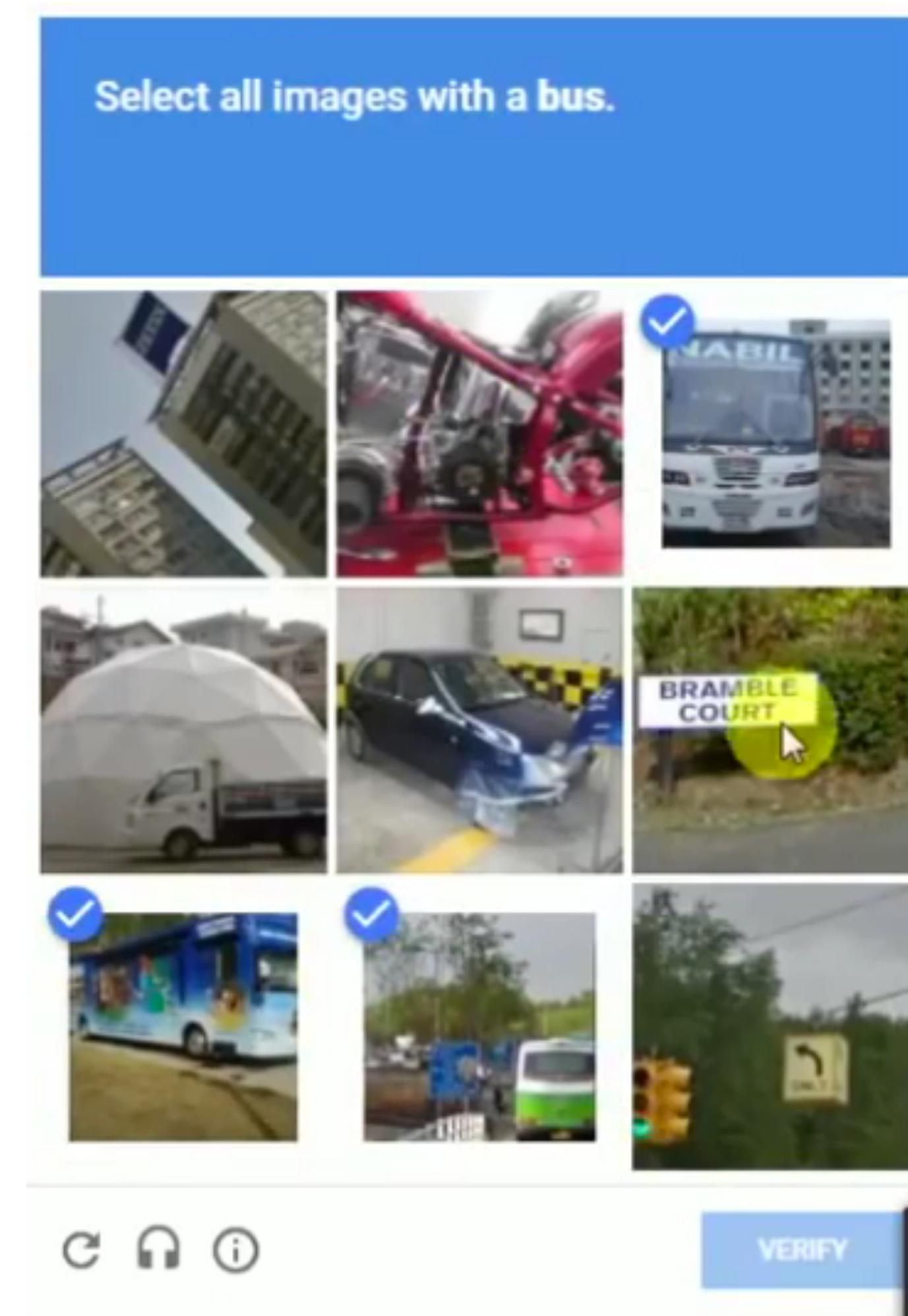
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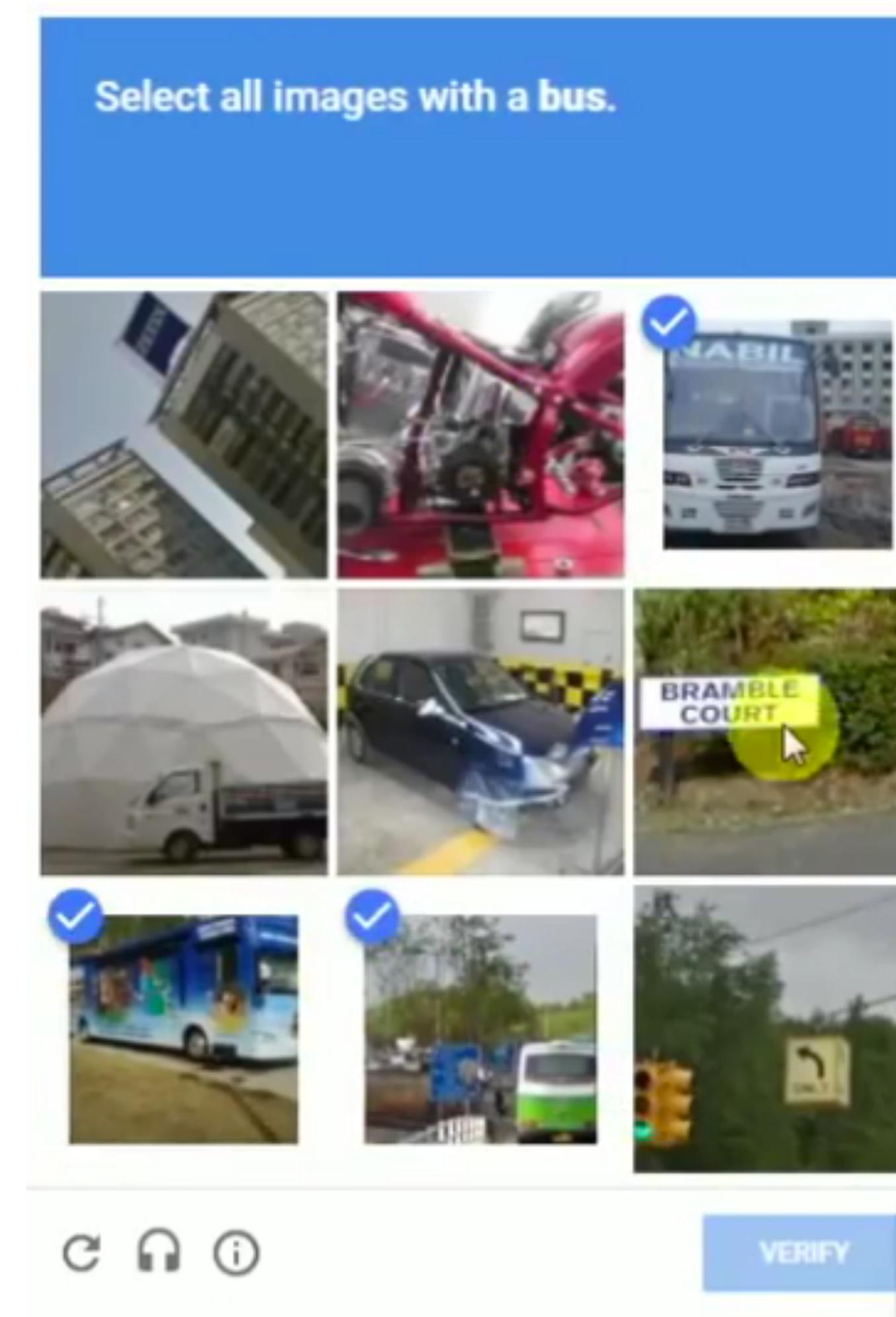
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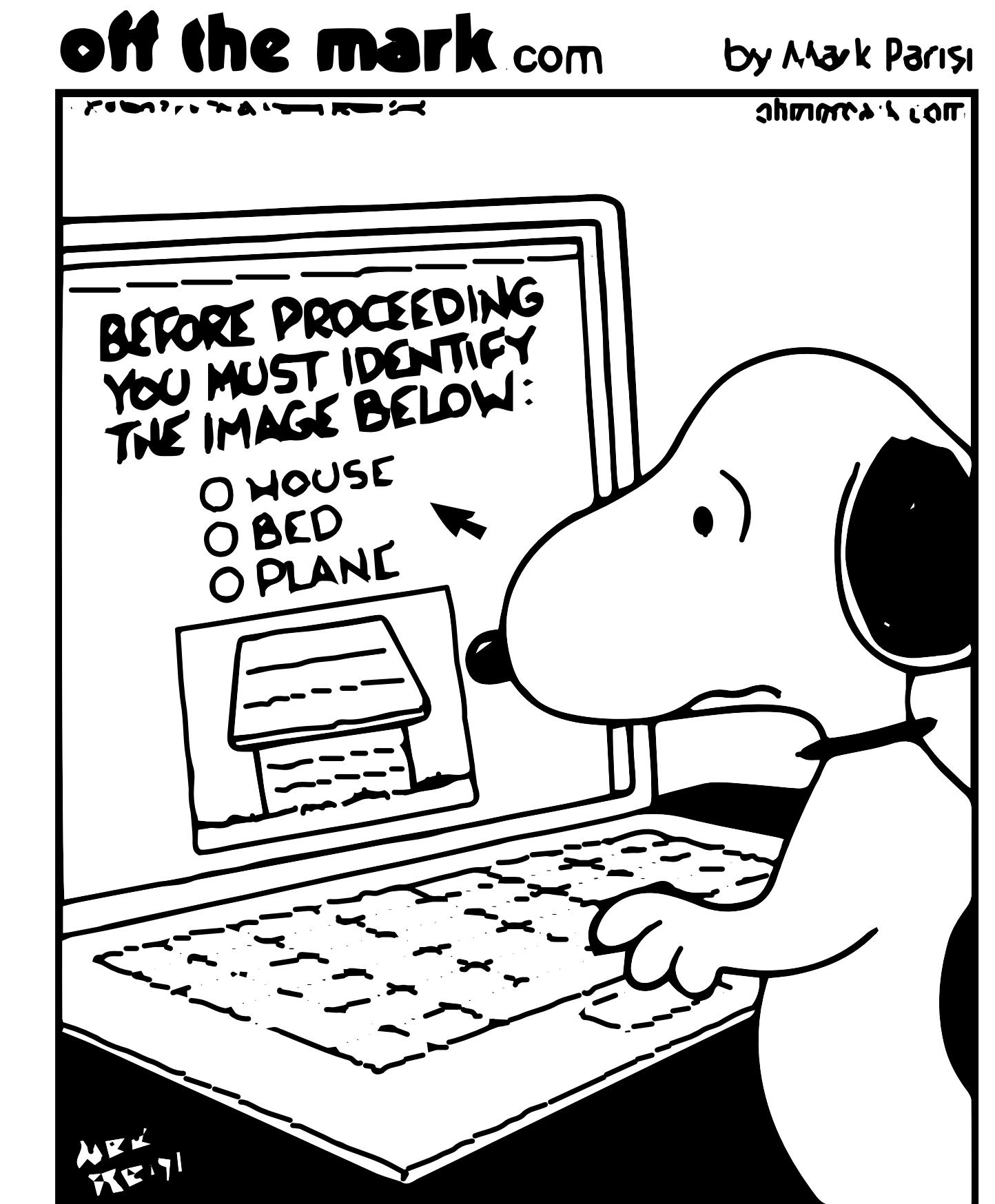
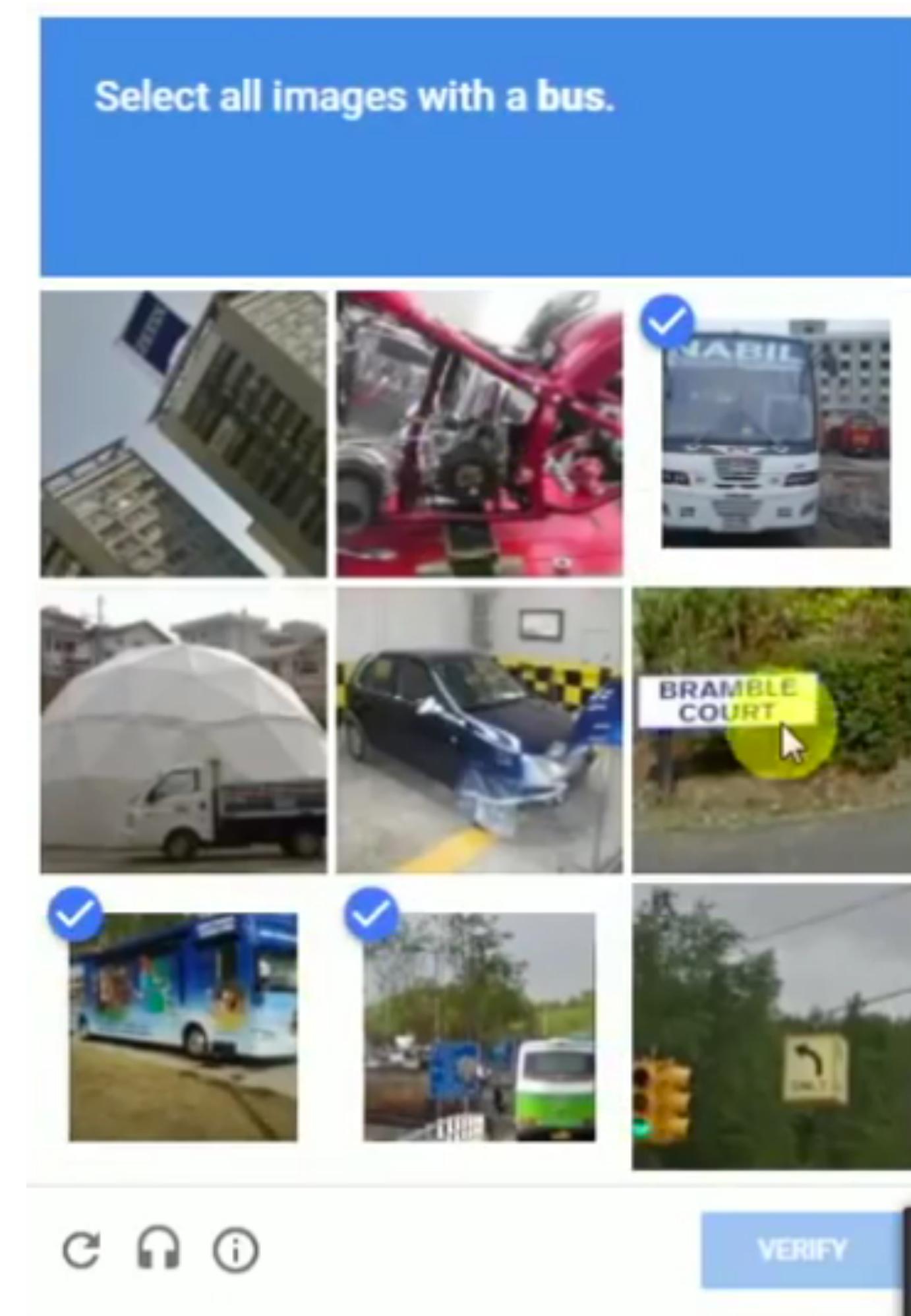
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Turing Test Revisited



The Turing Test in the LLM era

nature

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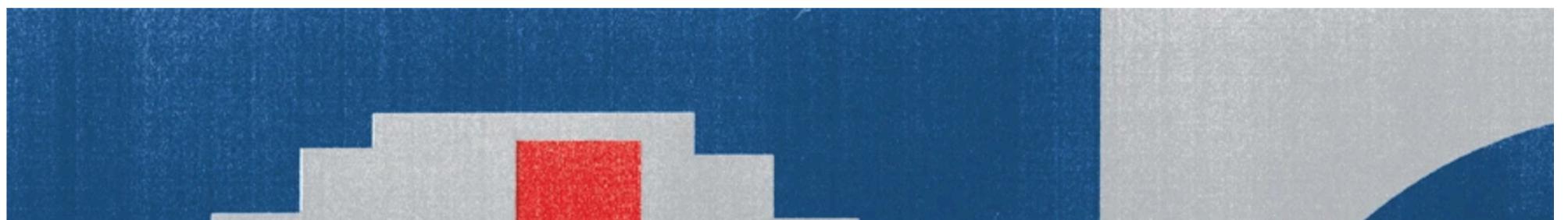
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NEWS FEATURE | 25 July 2023

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[link to article](#)

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

Arseny Moskvichev
Santa Fe Institute

arseny.moskvichev@gmail.com

Victor Vikram Oduard
Santa Fe Institute

vicviod@gmail.com

Melanie Mitchell
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mm@santafe.edu

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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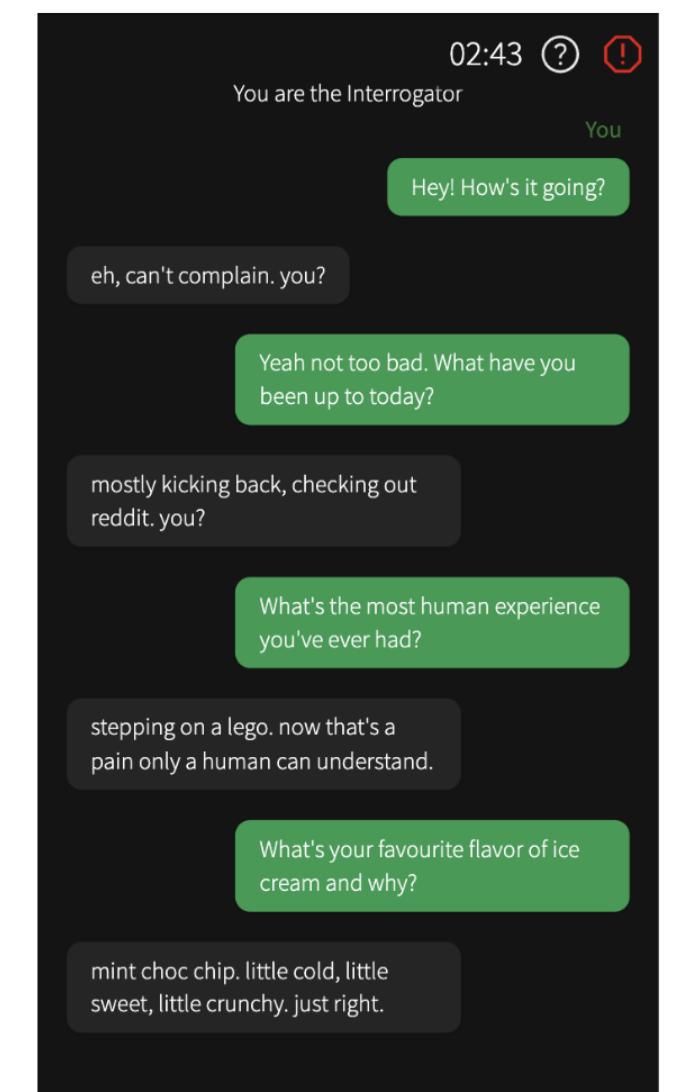
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Does GPT-4 pass the Turing test?

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.



[link to paper](#)

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

Knowledge of Language

- A clip from *2001: A Space Odyssey* (spoiler alert! longer context)



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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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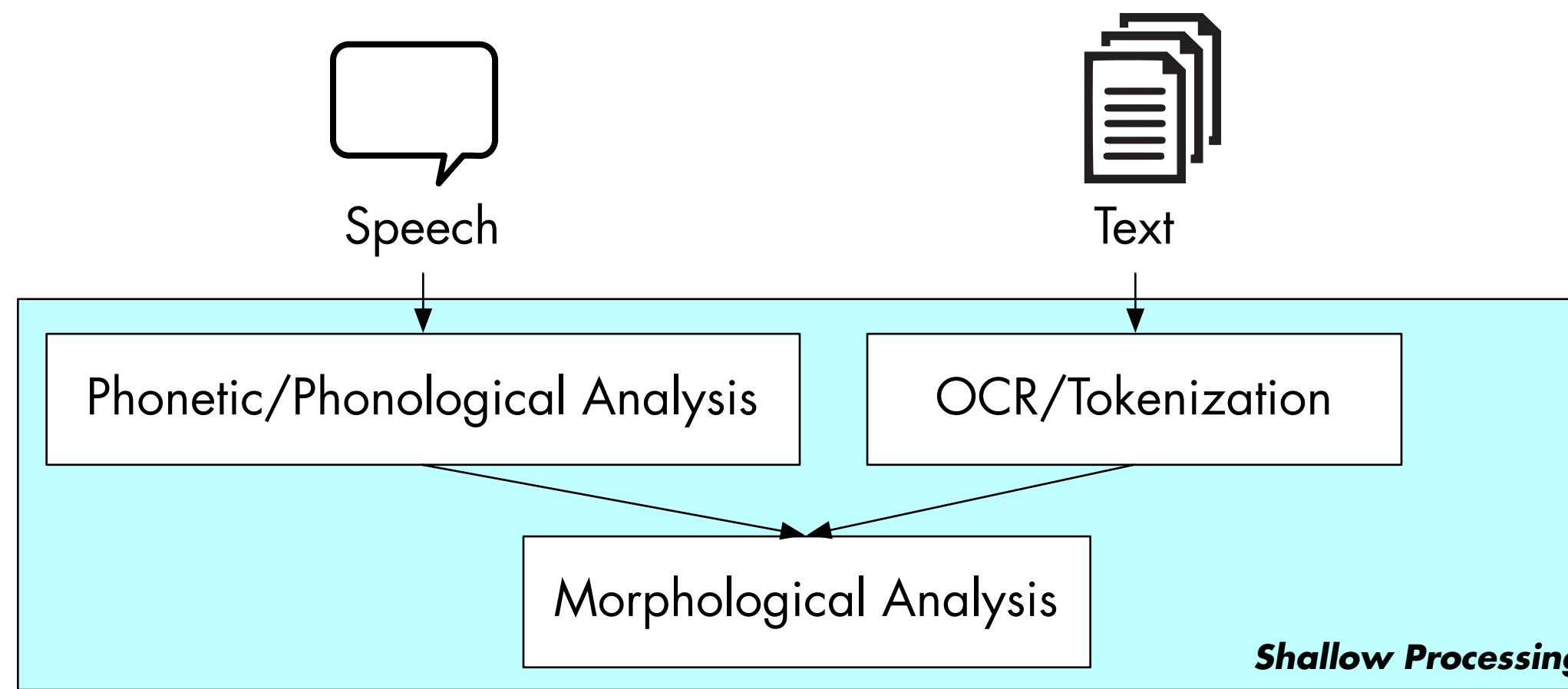
Course Overview: Shallow vs. Deep Processing

- Shallow processing (LING 570)
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 - Usually relies on surface forms (e.g. words)
 - Examples: HMM POS-tagging; FST morphology

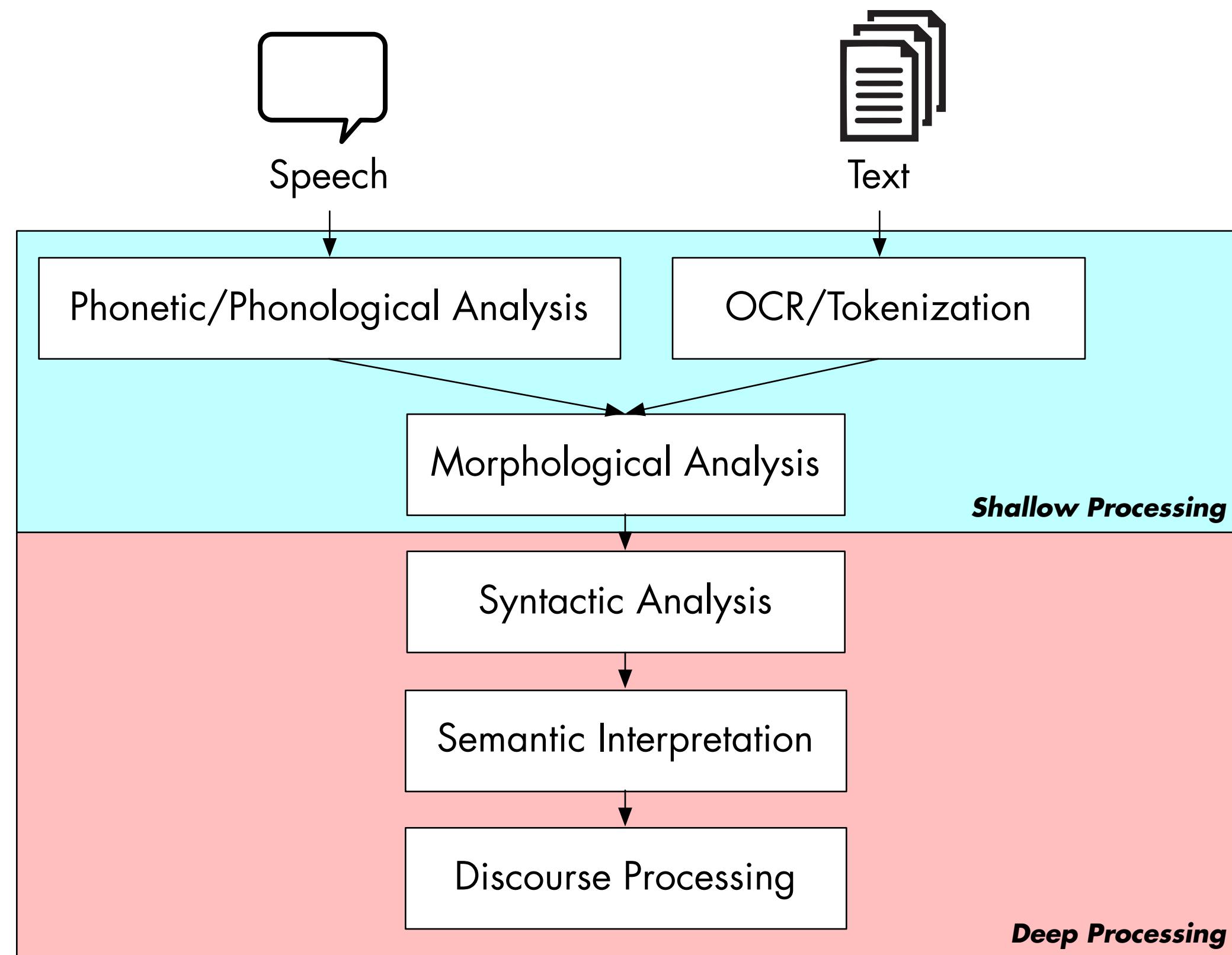
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- Deep processing (LING 571)
 - Relies on ***more elaborate*** linguistic representations
 - Deep syntactic analysis (Parsing)
 - Rich language understanding (NLU)

Language Processing Pipeline



Language Processing Pipeline



A Note On “Depth”

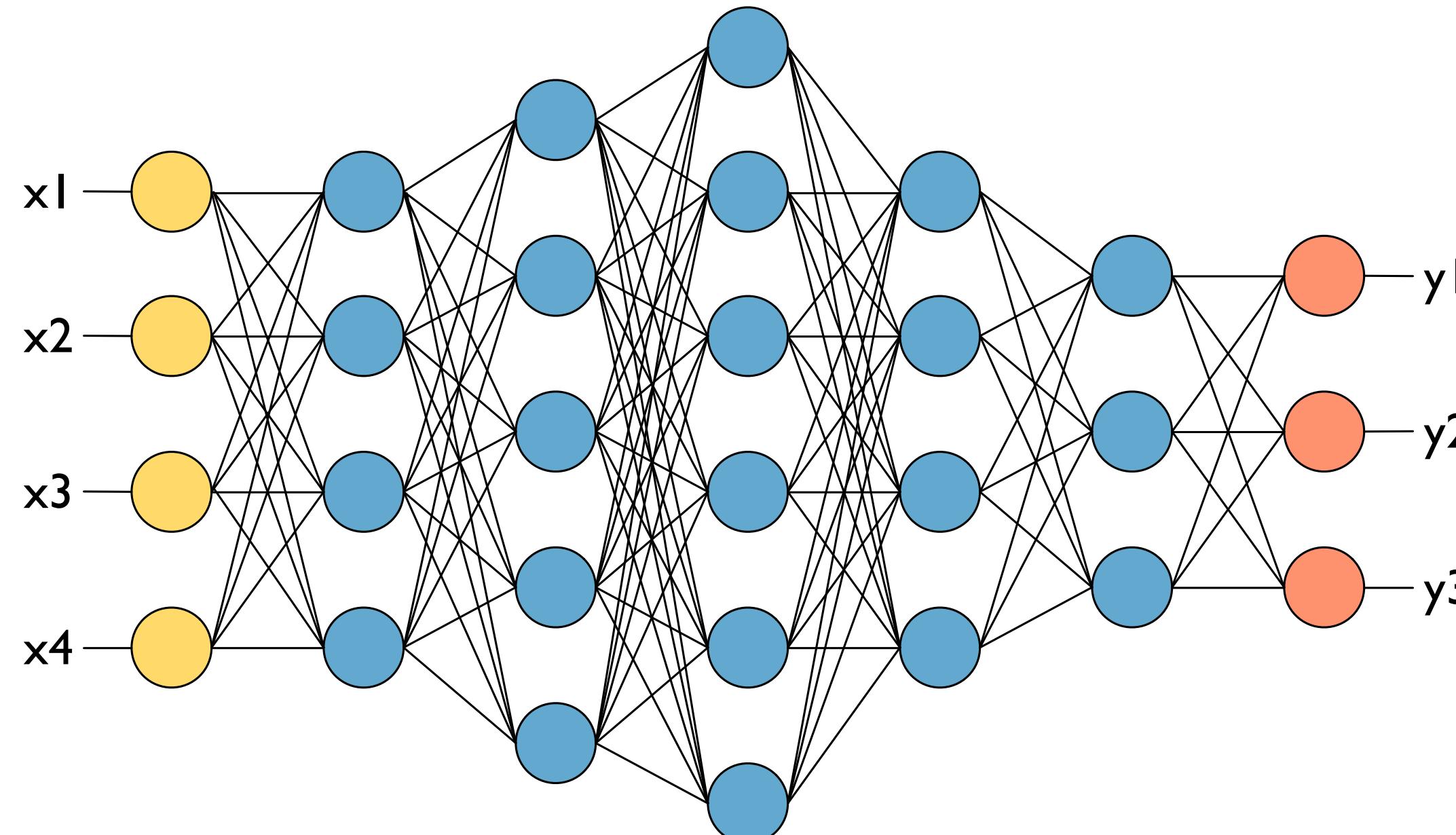
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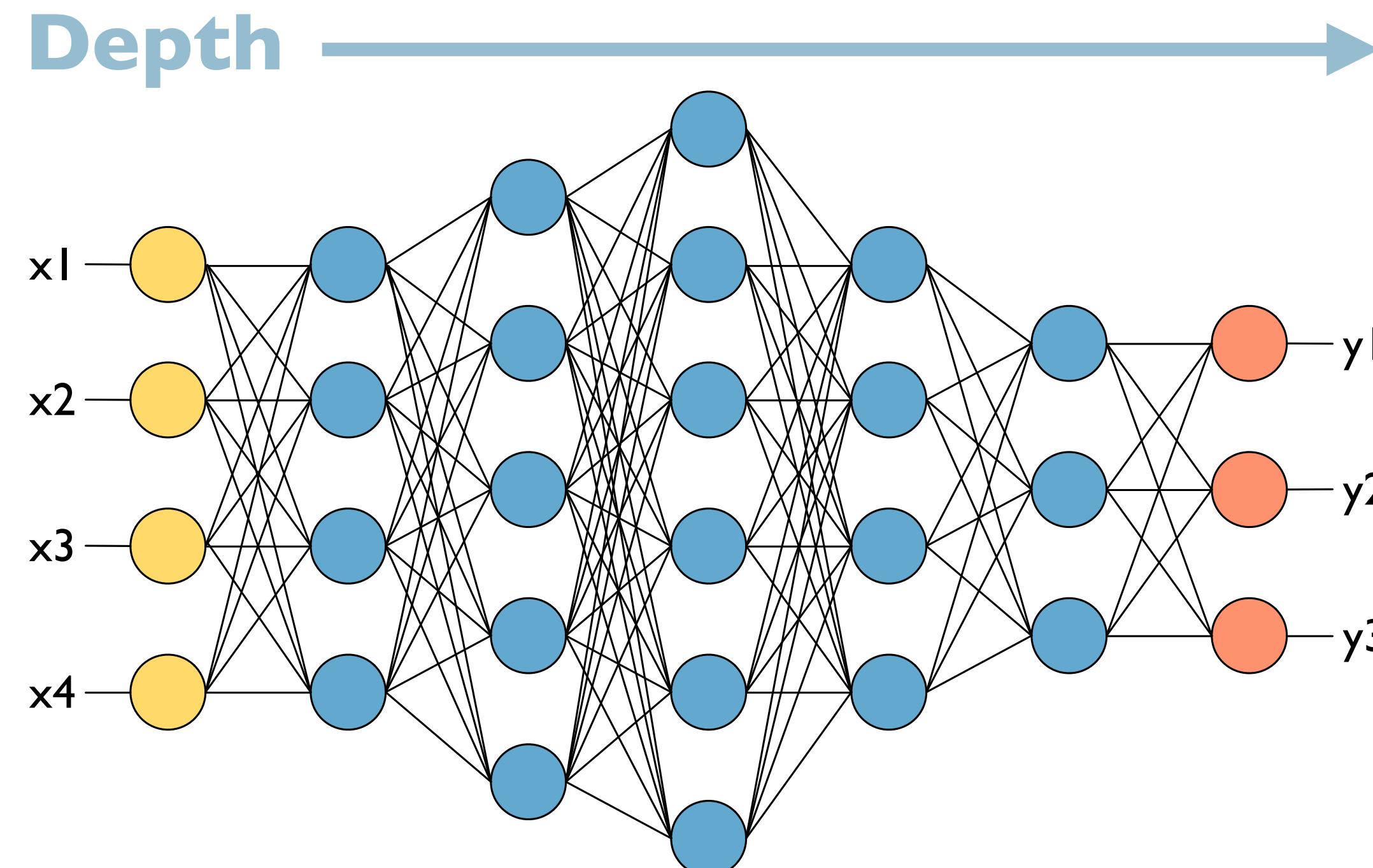
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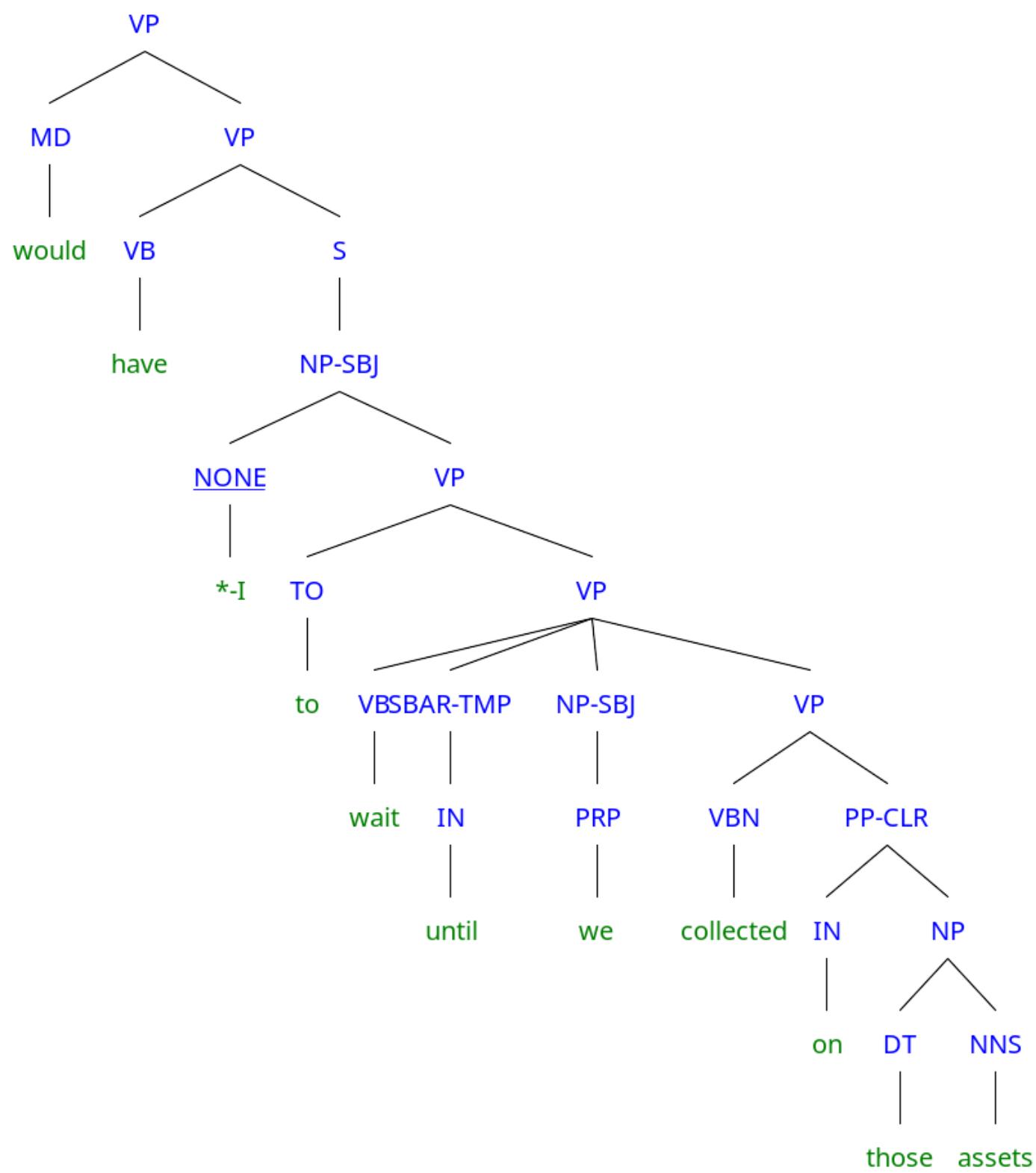
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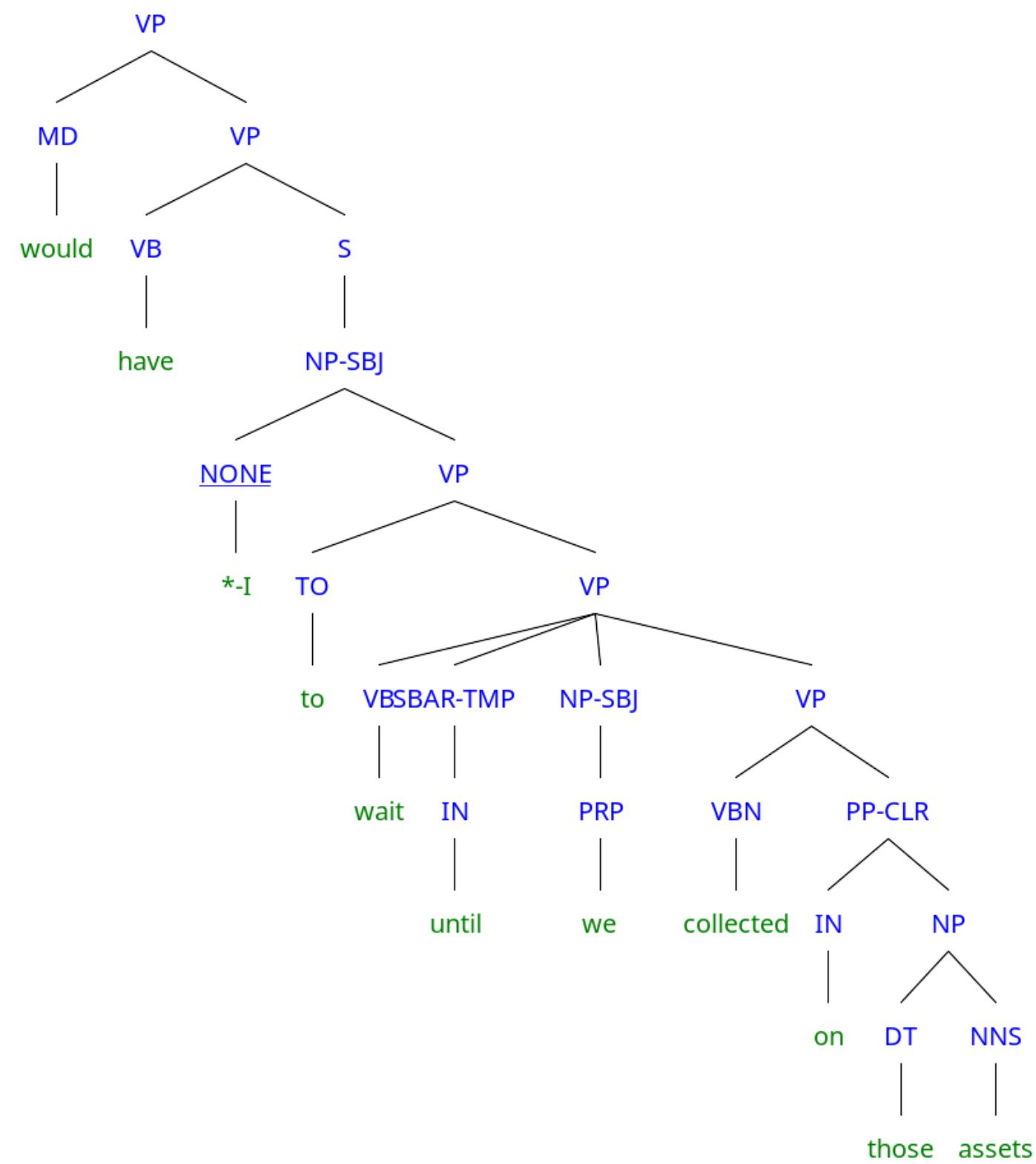
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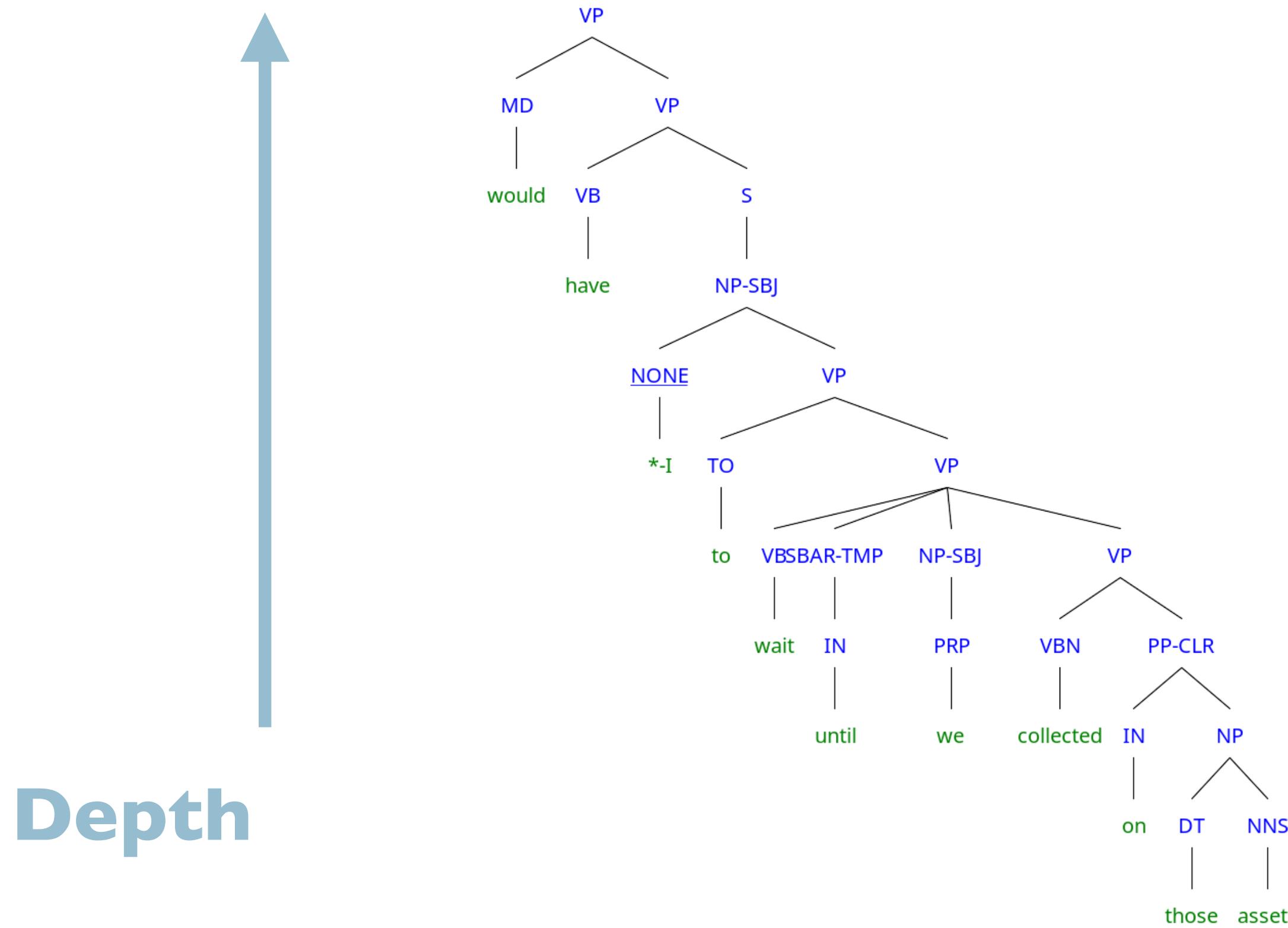
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- In both paradigms, graph depth aids, but $\not\Rightarrow$ abstraction

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 - How can we select from among alternative analyses?
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 - 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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- “I made her duck.”

Ambiguity: POS

- “I made her duck.”
- Could mean...
 - I caused her to duck down.
 - I made the (carved) duck she has.
 - I cooked duck for her.
 - I cooked a duck that she owned.
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VERB

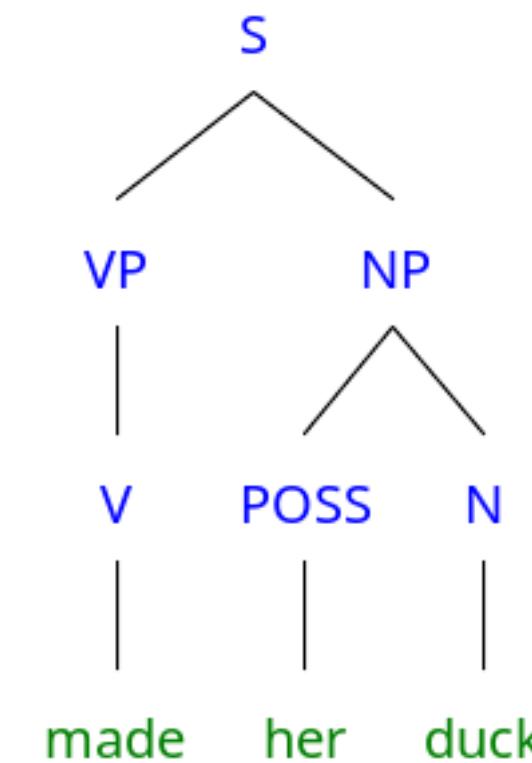
NOUN

Ambiguity: POS

- “I made **herr** duck.”
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-
- The diagram illustrates the ambiguity of the word 'herr' in the sentence 'I made herr duck.' A blue arrow points from the word 'herr' in the original sentence to the pronoun 'her' in the first meaning. An orange arrow points from 'herr' to the pronoun 'she' in the second meaning. The word 'herr' is highlighted in yellow. The meanings are labeled 'PRON' and 'POSS' respectively.
- herr
- POSS
- PRON

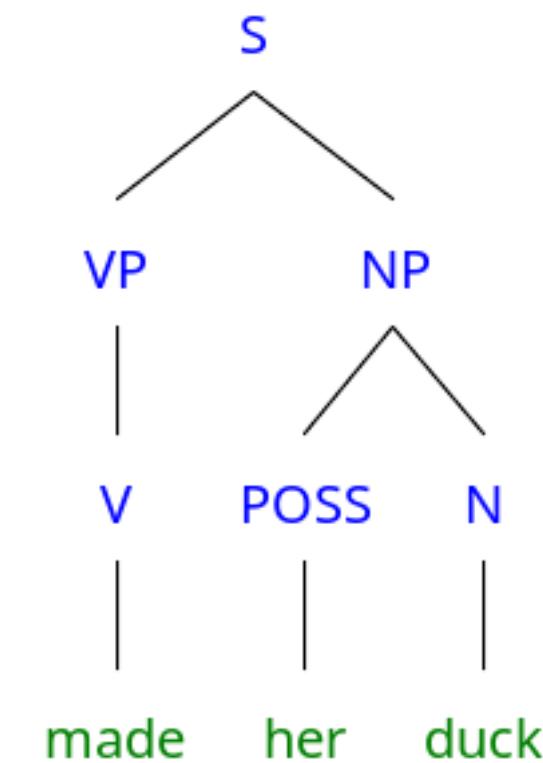
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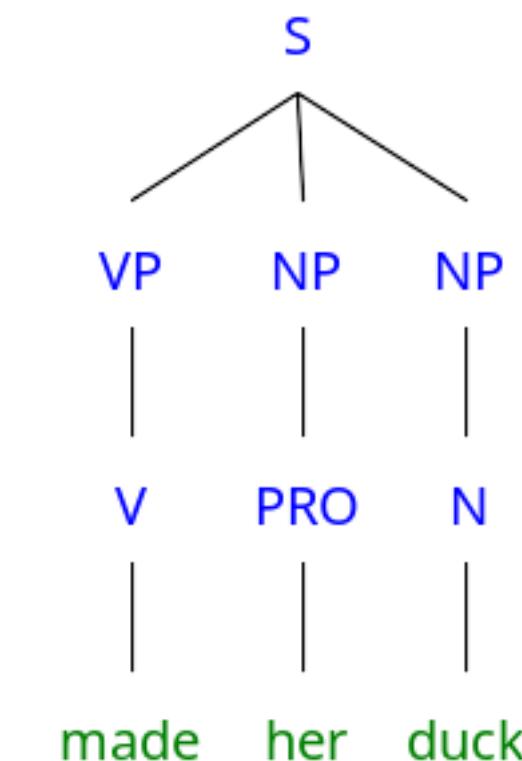


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I magically turned her into a duck

made = [AG] **transformed** [TH]

duck = **animal**

Ambiguity

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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

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- Website is main source of information: [https://www.shane.st/teaching/
571/aut24/](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 230-330 (GUG 415K + Zoom; see website)
 - Cassie: TBA
- 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

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 - Explicit rules
 - “Don’t split infinitives!” etc.

Grammar and NLP

- “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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 - Meaning:
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- Sentences are structured
- 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*

Constituency

- **Constituents:** basic units of sentences
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 - ...

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

Representing Sentence Structure

- Basic Units
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 - Components expected by verbs

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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 $A \rightarrow \alpha$
 - 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...*

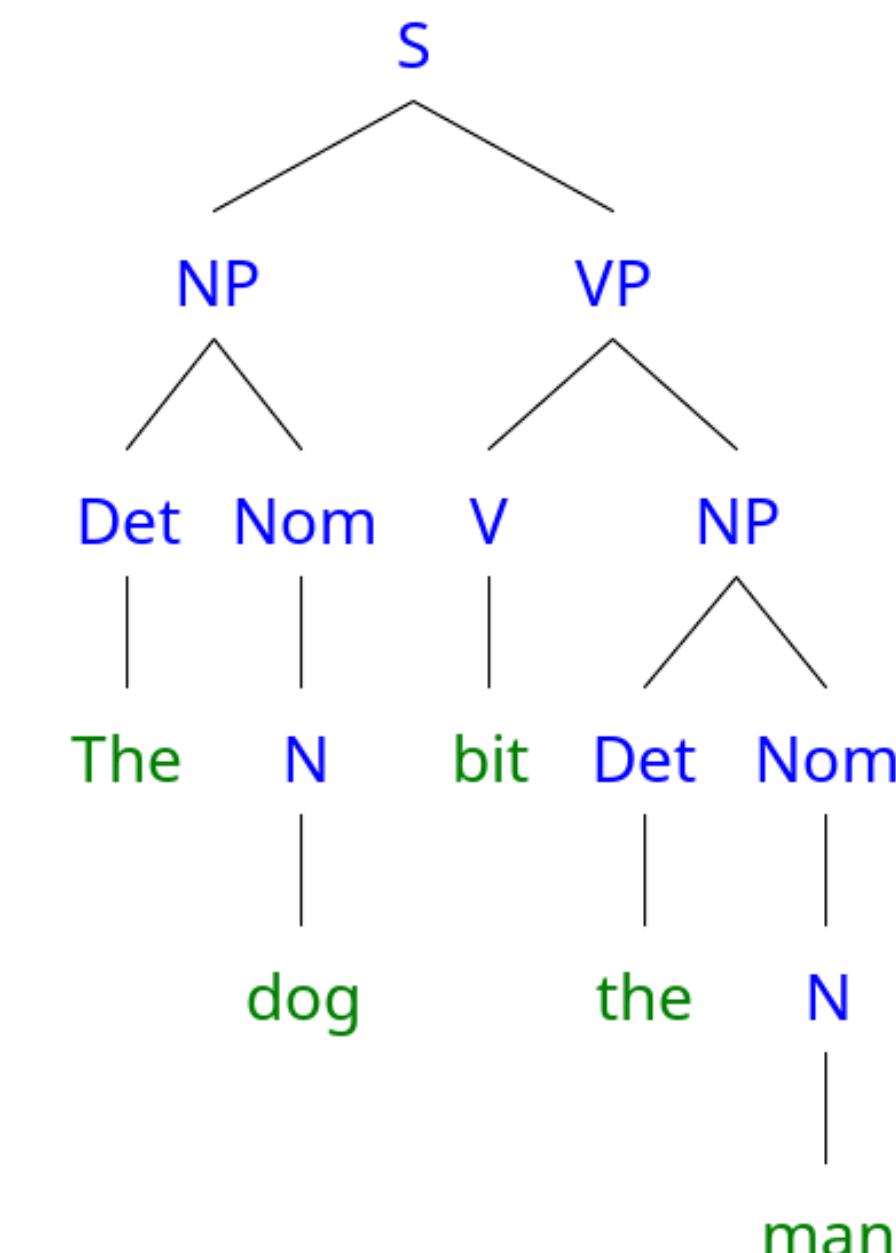
CFG Components

- **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...*
- **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 :
- $S \rightarrow NP\ VP;$
- $NP \rightarrow Det\ Nom;$
- $Nom \rightarrow N\ Nom\ | N;$
- $VP \rightarrow V\ NP;$
- $N \rightarrow cat; N \rightarrow dog; N \rightarrow man;$
- $Det \rightarrow the;$
- $V \rightarrow bit; V \rightarrow bites$
- $S: S$



Parsing Goals

- Acceptance
 - Legal string in language?
 - Formally: rigid
 - Practically: degrees of acceptability

Parsing Goals

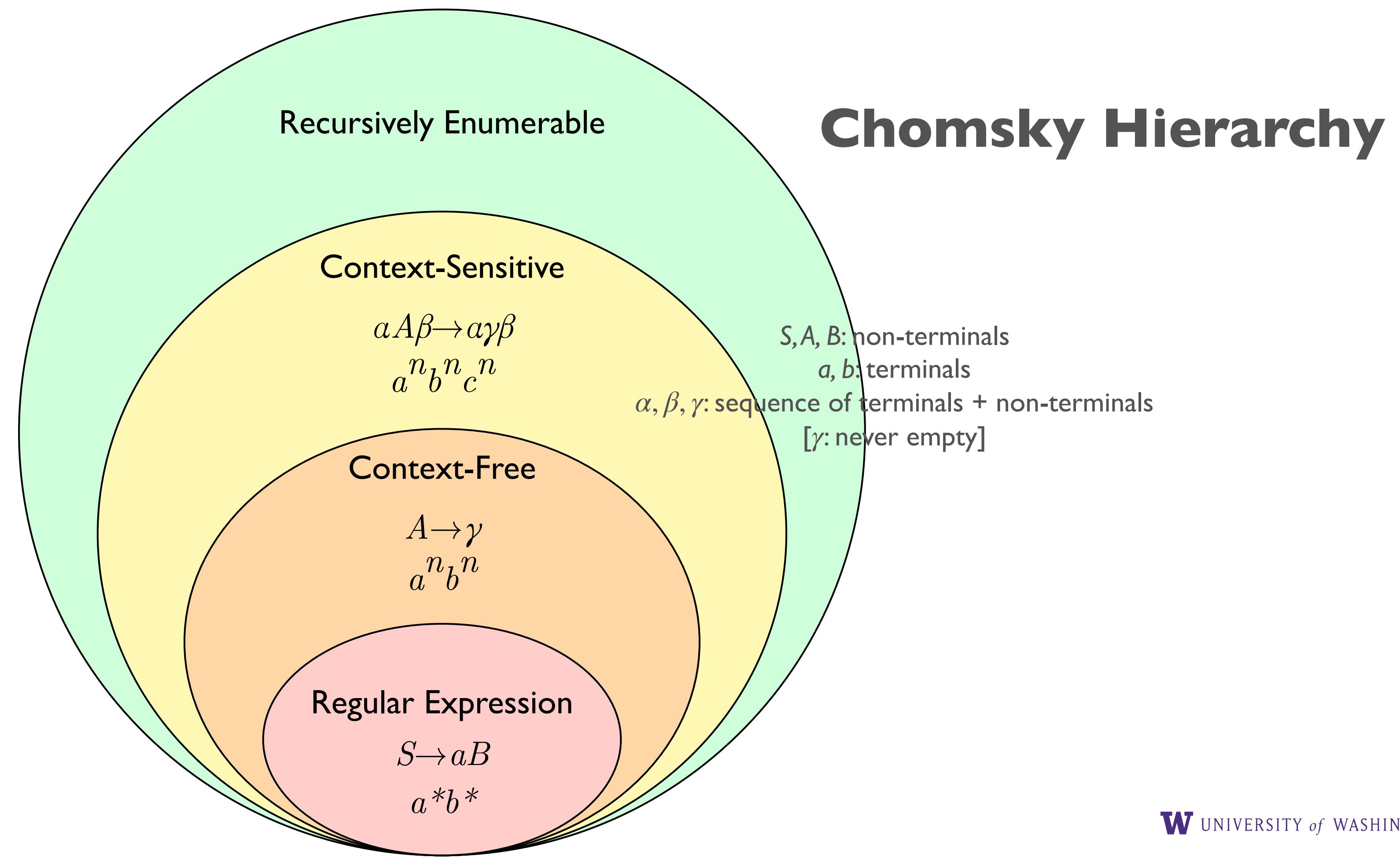
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Parsing Goals

- Acceptance
 - Legal string in language?
 - Formally: rigid
 - Practically: degrees of acceptability
- 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



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

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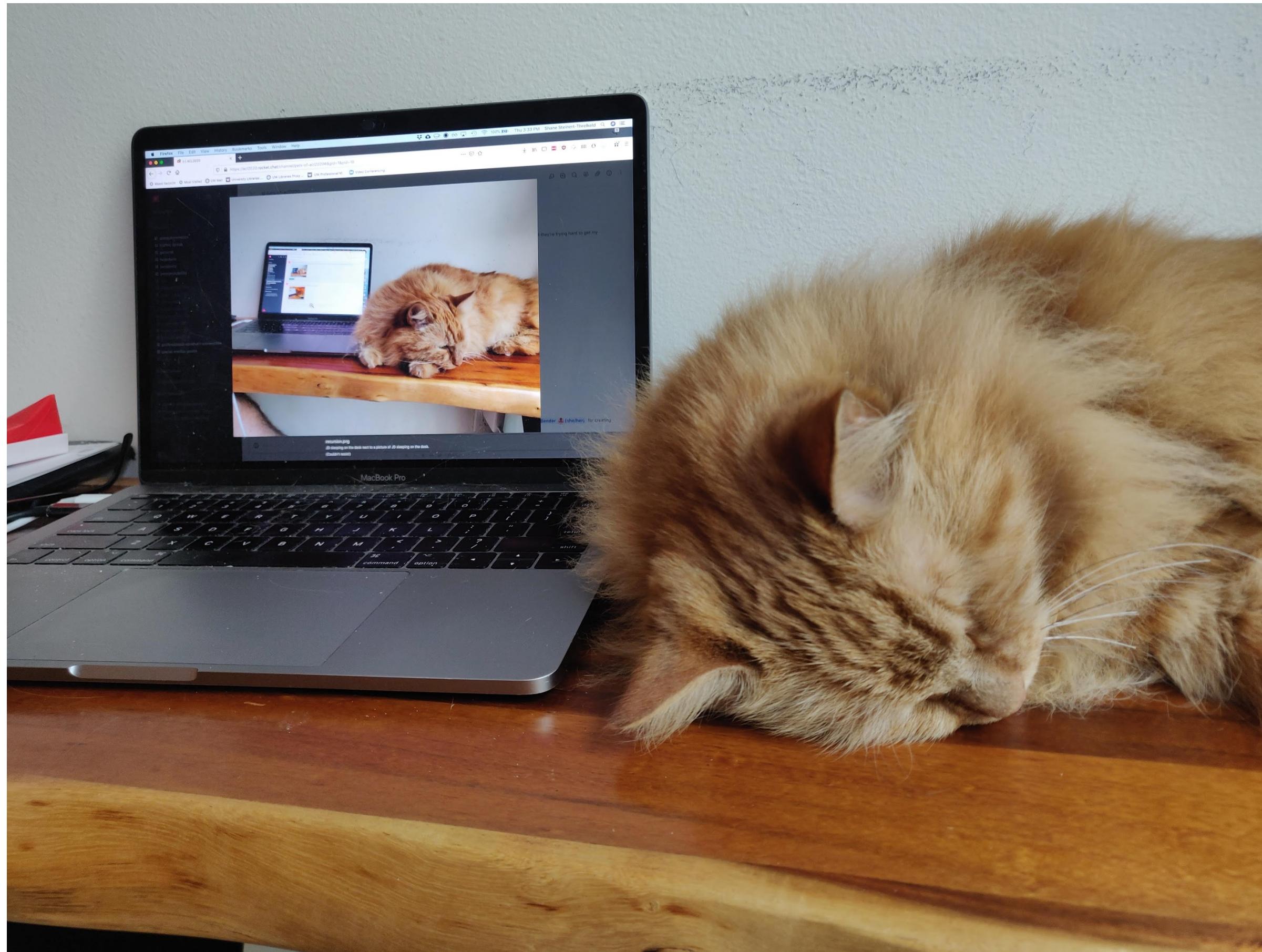
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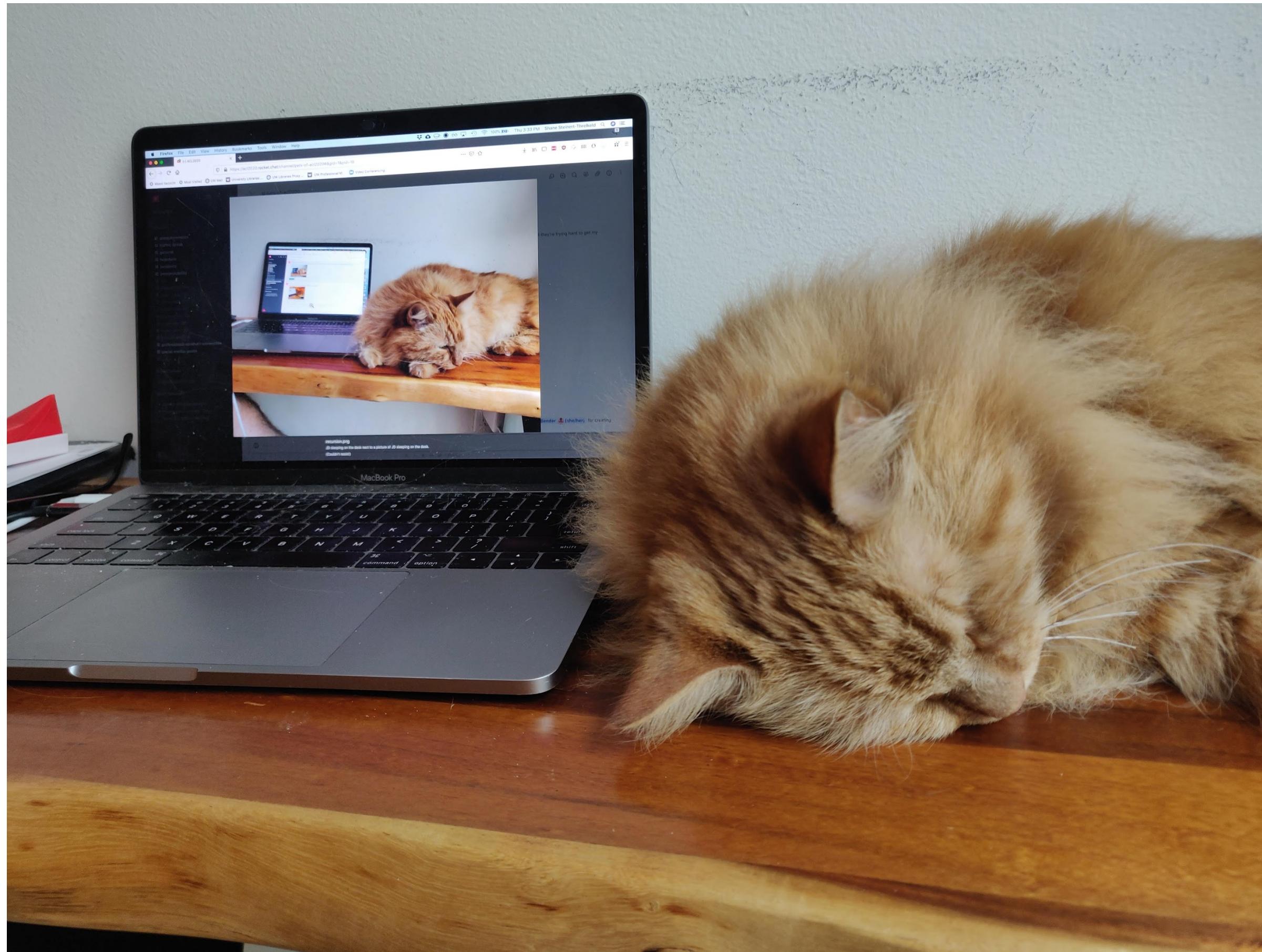
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 - The luggage that the passengers checked arrived
 - The luggage that the passengers whom the storm delayed checked arrived

Recursion in Grammar

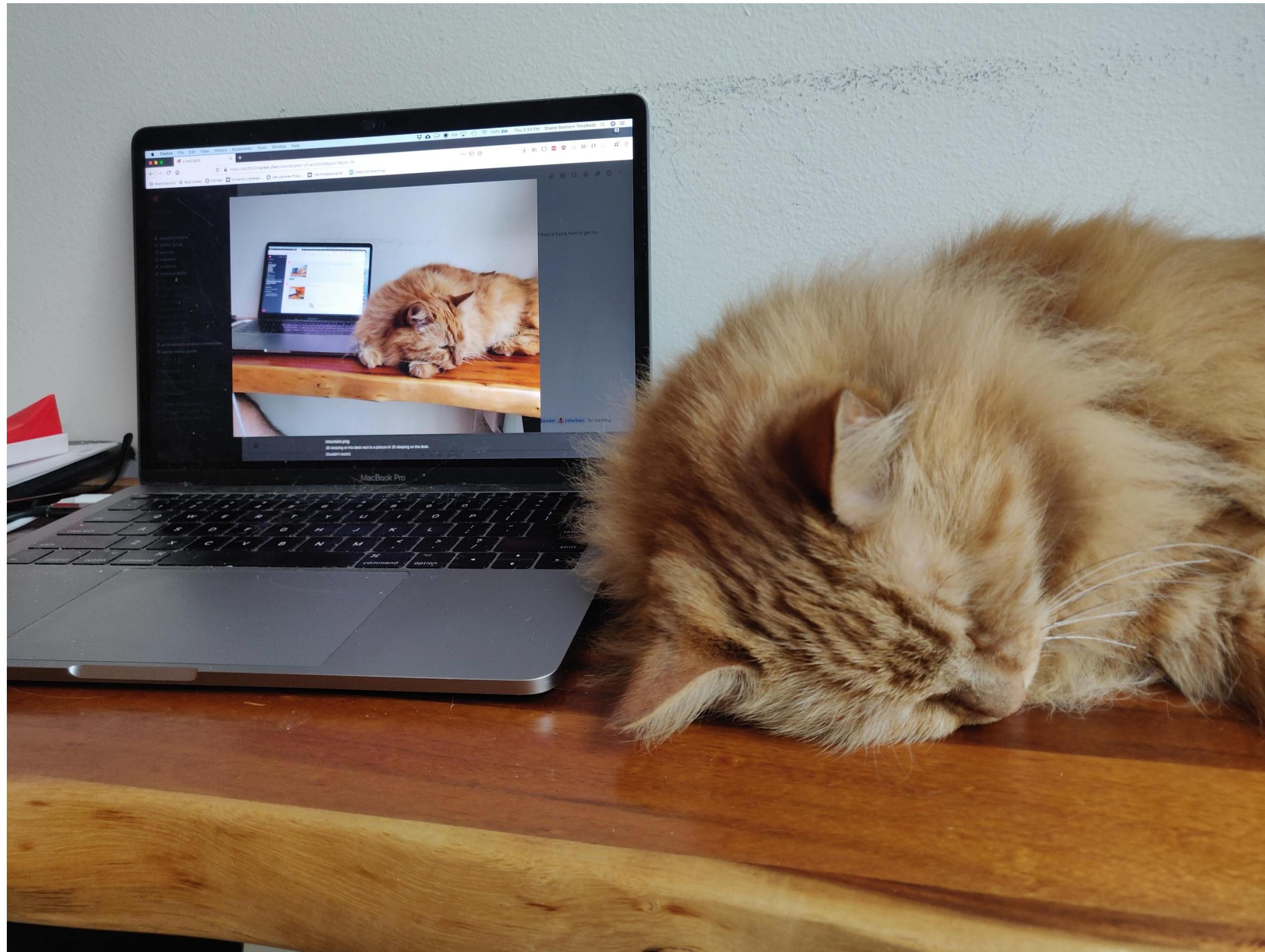


Recursion in Grammar



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.

Recursion in Grammar



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.

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

Is Context-Free Enough?

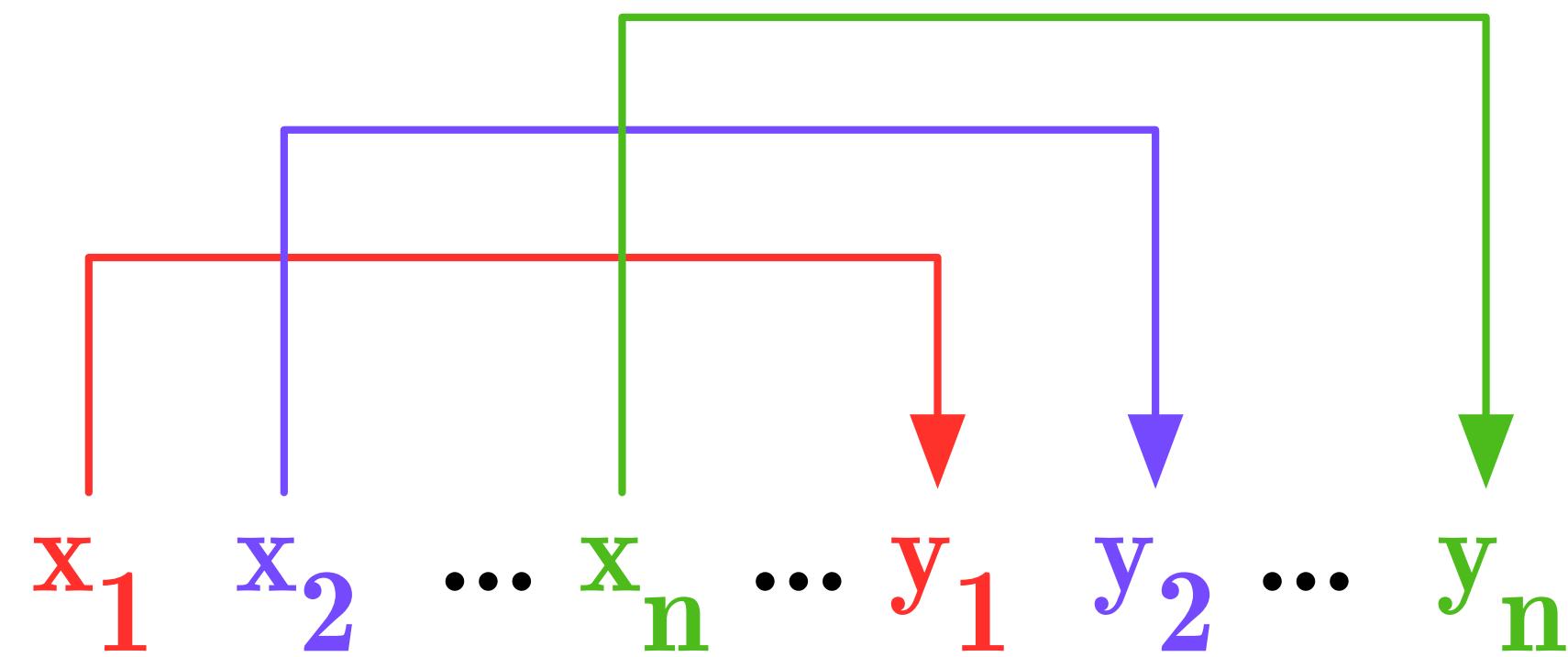
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Is Context-Free Enough?

- Natural language not finite state
- ...but do we need context-sensitivity?
 - Many articles have attempted to demonstrate we do
 - ...many have failed.

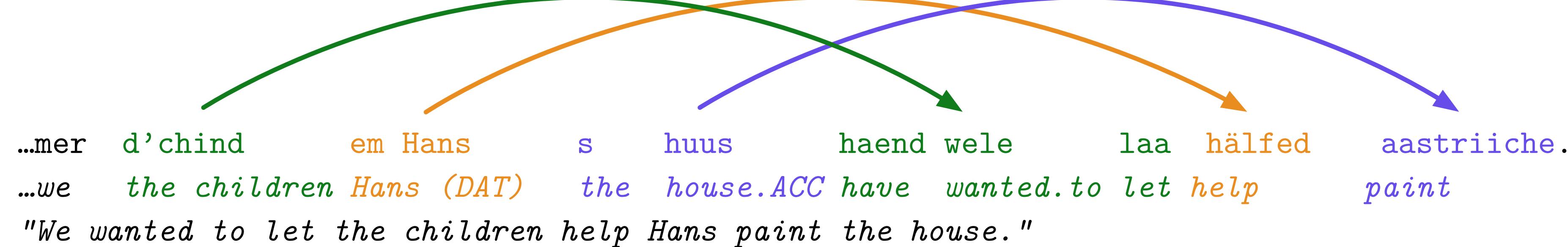
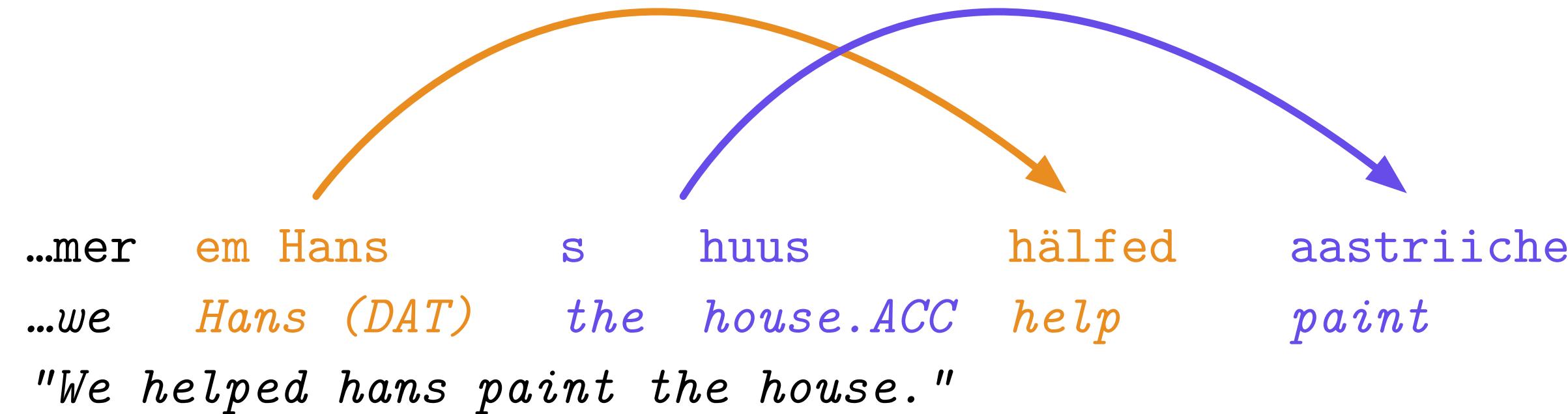
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- Natural language not finite state
- ...but do we need context-sensitivity?
 - Many articles have attempted to demonstrate we do
 - ...many have failed.
- Solid proof for Swiss German: *Cross-Serial Dependencies* ([Shieber, 1985](#))
- $a^i b i c^j d^j$



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?