## Homework

**Task:** use Wordnet to determine which words best match which definitions: **TWO QUIZZES ONLY!**

– (Quiz 64 from *Word Smart for the GRE*)

<table>
<thead>
<tr>
<th>Word</th>
<th>Definition</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>veritable</td>
<td>make ineffective</td>
<td>a.</td>
</tr>
<tr>
<td>vigilant</td>
<td>annoyance</td>
<td>b.</td>
</tr>
<tr>
<td>verisimilitude</td>
<td>characterize harshly</td>
<td>c.</td>
</tr>
<tr>
<td>vitiate</td>
<td>sticky</td>
<td>d.</td>
</tr>
<tr>
<td>vilify</td>
<td>watchful</td>
<td>e.</td>
</tr>
<tr>
<td>vexation</td>
<td>appearing true</td>
<td>f.</td>
</tr>
<tr>
<td>virulent</td>
<td>extremely harmful</td>
<td>g.</td>
</tr>
<tr>
<td>viscous</td>
<td>authentic</td>
<td>h.</td>
</tr>
</tbody>
</table>
## Homework

– (Quiz 65 from *Word Smart for the GRE*)

<table>
<thead>
<tr>
<th>Word</th>
<th>Definition</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1. zealous</td>
<td>be in turmoil</td>
<td>a.</td>
</tr>
<tr>
<td>2. waft</td>
<td>ravenous</td>
<td>b.</td>
</tr>
<tr>
<td>3. waver</td>
<td>be unsettled in opinion</td>
<td>c.</td>
</tr>
<tr>
<td>4. vituperate</td>
<td>censure severely</td>
<td>d.</td>
</tr>
<tr>
<td>5. wend</td>
<td>impassioned</td>
<td>e.</td>
</tr>
<tr>
<td>6. welter</td>
<td>go</td>
<td>f.</td>
</tr>
<tr>
<td>7. voracious</td>
<td>light breeze</td>
<td>g.</td>
</tr>
<tr>
<td>8. volatile</td>
<td>changeable</td>
<td>h.</td>
</tr>
</tbody>
</table>
Homework

• You can have another week.
• Please try to use the bfs code
• WordNet::Similarity is another possibility — recall *star* and *telescope*?

**Results:**

The relatedness of *telescope* and *star* using vector is 0.2545.
The relatedness of *telescope* and *star* using jcn is 0.0647.
The relatedness of *telescope* and *star* using wup is 0.5.
The relatedness of *telescope* and *star* using res is 1.3696.
The relatedness of *telescope* and *star* using lesk is 19.
The relatedness of *telescope* and *star* using path is 0.0909.
The relatedness of *telescope* and *star* using lin is 0.1506.
The relatedness of *telescope* and *star* using vector_pairs is 0.021.
The relatedness of *telescope* and *star* using hso is 0.
The relatedness of *telescope* and *star* using lch is 1.291.

View relatedness of all senses (without traces)
View relatedness of all senses (with traces)
View traces
WordNet::Similarity

• Online version
  – http://marimba.d.umn.edu/cgi-bin/similarity/similarity.cgi

• Perl Module:
  https://metacpan.org/pod/WordNet::Similarity
WordNet::Similarity

- Perl Module:  
  - https://metacpan.org/pod/WordNet::Similarity

```perl
use WordNet::QueryData;
use WordNet::Similarity::path;
my $wn = WordNet::QueryData->new;
my $measure = WordNet::Similarity::path->new ($wn);
my $value = $measure->getRelatedness("car\#n\#1", "bus\#n\#2");
my ($error, $errorString) = $measure->getError();
die $errorString if $error;
print "car (sense 1) <-> bus (sense 2) = $value\n";
```
Other Lexical Resources

• Framenet
  – https://framenet.icsi.berkeley.edu/fndrupal/
Predicate-Argument Structure

- **Example**:  
  - John ate the sandwich  
  - *eat*: predicate  
  - *eat* has two arguments: eater, something that is eaten  
  - eater = John  
  - something to be eaten = *the sandwich*

- **A Possible Representation**  
  - *in Prolog term-like notation*  
  - eat(<eater>,<something to be eaten>)  
  - eat(john,sandwich)

- **Linguists generally try to choose more general labels for the arguments**  
  - *less verb-specific*  
  - eat(<agent>,<patient>)  
  - <agent> someone/something who performs some action  
  - <patient> undergoes change of state etc.  
  - eat(<agent>,<theme>)  
  - <theme> something applies to this argument but doesn’t undergo change of state
Predicate-Argument Structure

It can be difficult to precisely specify the meaning of the arguments via thematic labels of this sort
•  [http://en.wikipedia.org/wiki/Thematic_relations]
•  Here is a list of the major thematic relations.

•  **Agent:**
  – deliberately performs the action
  – (e.g. Bill ate his soup quietly)

•  **Experiencer:**
  – receives sensory or emotional input
  – (e.g. The smell of lilies filled Jennifer's nostrils).

•  **Theme:**
  – undergoes the action but does not change its state
  – (Sometimes used interchangeably with patient)
  – (e.g. Bill kissed Mary).

•  **Patient:**
  – undergoes the action and has its state changed
  – (Sometimes used interchangeably with theme)
  – (e.g. The falling rocks crushed the car).

•  **Instrument:**
  – used to carry out the action
  – (e.g. Jamie cut the ribbon with a pair of scissors).

•  **Natural Cause:**
  – mindlessly performs the action
  – (e.g. An avalanche destroyed the ancient temple).

•  **Location:**
  – where the action occurs
  – (e.g. Johnny and Linda played carelessly in the park).

•  **Goal:**
  – what the action is directed towards
  – (e.g. The caravan continued on toward the distant oasis).

•  **Recipient:**
  – a special kind of goal associated with verbs expressing a change in ownership, possession.
  – (e.g I sent John the letter)

•  **Source:**
  – where the action originated
  – (e.g. The rocket was launched from Central Command).

•  **Time:**
  – the time at which the action occurs
  – (e.g. The rocket was launched yesterday).

•  **Beneficiary:**
  – the entity for whose benefit the action occurs
  – (e.g. I baked Reggie a cake)
Predicate-Argument Structure

• **Passives**
  
  – The sandwich was eaten by John
  – John ate the sandwich
  – eat(<eater>,<object to undergo eating>)
  – eat(<agent>,<patient>)
  – eat(john,sandwich)

  – The sandwich was eaten
  – eat(_,sandwich)

  – an incomplete or underspecified predicate argument structure

• **Not all Noun Phrases seem to have a meaningful thematic relation associated with them**
  
  – It rains
  – It is likely that John ate the sandwich
  – John is likely to eat the sandwich
  – It seems that John ate the sandwich
  – John seemed to eat the sandwich
  – There seems to be a sandwich over there
  – A sandwich seems to be over there
Framenet

- Lexical unit index:
  - https://framenet.icsi.berkeley.edu/fndrupal/index.php?q=luIndex

Let's take a look at LU *eat*
Frame: Ingestion

Ingestion

https://framenet.icsi.berkeley.edu/

Definition:

An Ingestor consumes food or drink (Ingestibles), which entails putting the Ingestibles in the mouth for delivery to the digestive system. This may include the use of an Instrument. Sentences that describe the provision of food to others are NOT included in this frame.

FEs:

Core:

Ingestibles [Ingible]

The Ingestibles are the entities that are being consumed by the Ingestor.

Ingestor [Ing]

The Ingestor is the person eating or drinking.

Semantic Type: Sentient

Non-Core:

Degree [Degr]

The extent to which the Ingestibles are consumed by the Ingestor.

Semantic Type: Degree

The wolves DEVoured the carcass completely.

Duration [Dur]

The length of time spent on the ingestion activity.

They've been EATING for hours!
Frame: Ingestion

Duration [Dur]
The length of time spent on the ingestion activity. They’ve been **EATING** for hours!

Instrument [Ins]
Semantic Type: Physical_entity
The **Instrument** with which an intentional act is performed.

Manner [Manr]
Semantic Type: Manner
**Manner** of performing an action.

Means [Mns]
Semantic Type: State_of_affairs
An act performed by the **Ingestor** that enables them to accomplish the whole act of ingestion.

The thing **ATE** by **snaking its long tongue out and grabbing with it**.

Place [Place]
Semantic Type: Locative_relation
Where the event takes place.

Purpose [pur]
Semantic Type: State_of_affairs
The action that the **Ingestor** hopes to bring about by ingesting.

Source [Src]
Semantic Type: Source
Place from which the **Ingestor** takes the **Ingestibles**.

Time [Time]
Semantic Type: Time
When the event occurs.
Frame: Ingestion

Frame-frame Relations:
Inherits from: Ingest_substance, Manipulation
Is Inherited by:
Perspective on:
Is Perspectivized in:
Uses: Cause_motion
Is Used by: Food, Tasting
Subframe of:
Has Subframe(s):
Precedes:
Is Preceded by:
Is Inchoative of:
Is Causative of:
See also:

Lexical Units:
breakfast.v, consume.v, devour.v, dine.v, down.v, drink.v, eat.v, feast.v, feed.v, gobble.v, gulp.n, gulp.v, guzzle.v, have.v, imbibe.v, ingest.v, lap.v, lunch.v, munch.v, nibble.v, nosh.v, nurse.v, put away.v, put back.v, quaff.v, sip.n, sip.v, slurp.n, slurp.v, snack.v, sup.v, swig.n, swig.v, swill.v, tuck.v
Example

WordNet Search - 3.1
- WordNet home page - Glossary - Help

Word to search for: eat  Search WordNet

Display Options: (Select option to change)  Change

Key: "S:" = Show Synset (semantic) relations, "W:" = Show Word (lexical) relations
Display options for sense: (gloss) "an example sentence"

Verb

- S: (v) eat (take in solid food) "She was eating a banana"; "What did you eat for dinner last night?"
- S: (v) eat (eat a meal; take a meal) "We did not eat until 10 P.M. because there were so many phone calls"; "I didn't eat yet, so I gladly accept your invitation"
- S: (v) feed, eat (take in food; used of animals only) "This dog doesn't eat certain kinds of meat"; "What do whales eat?"
- S: (v) eat, eat on (worry or cause anxiety in a persistent way) "What's eating you?"
- S: (v) consume, eat up, use up, eat, deplete, exhaust, run through, wipe out (use up (resources or materials)) "this car consumes a lot of gas"; "We exhausted our savings"; "They run through 20 bottles of wine a week"
- S: (v) corrode, eat, rust (cause to deteriorate due to the action of water, air, or an acid) "The acid corroded the metal"; "The steady dripping of water rusted the metal stopper in the sink"
Example

Verb

- **S**: (v) **eat** (take in solid food) "She was eating a banana"; "What did you eat for dinner last night?"
  - **direct troponym** / full troponym
  - **verb group**
  - **entailment**
  - **direct hypernym** / **inherited hypernym** / sister term
- **S**: (v) **eat** (eat a meal; take a meal) "We did not eat until 10 P.M. because there were so many phone calls"; "I didn't eat yet, so I gladly accept your invitation"
- **S**: (v) **consume, ingest, take in, take, have** (serve oneself to, or consume regularly) "Have another bowl of chicken soup!"; "I don't take sugar in my coffee"
- **S**: (v) **consume, ingest, take in, take, have** (serve oneself to, or consume regularly) "Have another bowl of chicken soup!"; "I don't take sugar in my coffee"
  - **derivationally related form**
  - **sentence frame**
- **S**: (v) **eat** (eat a meal; take a meal) "We did not eat until 10 P.M. because there were so many phone calls"; "I didn't eat yet, so I gladly accept your invitation"
Lexical Units (LU):
breakfast.v, consume.v, devour.v, dine.v, down.v, drink.v, eat.v, feast.v, feed.v, gobble.v, gulp.n, gulp.v, guzzle.v, have.v, imbibe.v, ingest.v, lap.v, lunch.v, munch.v, nibble.v, nosh.v, nurse.v, put away.v, put back.v, quaff.v, sip.n, sip.v, slurp.n, slurp.v, snack.v, sup.v, swig.n, swig.v, swill.v, tuck.v

perl bfs3.perl eat#v#1 gobble#v#1
Found at distance 1 (11 nodes explored)
gobble#v#1 hypo eat#v#1
Example

Sense 1

eat#1  -- (take in solid food; "She was eating a banana"; "What did you eat for dinner last night?")
  => wash down#1  -- (eat food accompanied by lots of liquid; also use metaphorically; "She washed down her dinner with a bottle of red wine"; "He washed down his worries with a nightly glass of whisky")
  => gluttonize#1, gluttonise#1, fress#1  -- (eat a lot and without restraint)
  => wolf#1, wolf down#1  -- (eat hastily; "The teenager wolfed down the pizza")
  => slurp#1  -- (eat noisily; "He slurped his soup")
  => fare#2  -- (eat well)
  => pitch in#1, dig in#2  -- (eat heartily; "The food was placed on the table and the children pitched in")
  => pick at#2, peck at#1, peck#4  -- (eat like a bird; "The anorexic girl just picks at her food")
  => peck#2, pick up#15  -- (eat by pecking at, like a bird)
  => gobble#1, bolt#6  -- (eat hastily without proper chewing; "Don't bolt your food!")
  => garbage down#1, gobble up#1, shovel in#2, bolt down#2  -- (eat a large amount of food quickly; "The children gobbled down most of the birthday cake")
  => nibble#3, pick#12, piece#4  -- (eat intermittently; take small bites of; "He pieced at the sandwich all morning"; "She never eats a full meal--she just nibbles")
  => ruminate#1  -- (chew the cuds; "cows ruminate")
  => dunk#3, dip#2  -- (dip into a liquid while eating; "She dunked the piece of bread in the sauce")
  => devour#4, guttle#1, raven#3, pig#2  -- (eat greedily; "he devoured three sandwiches")
  => eat up#1, finish#5, polish off#3  -- (finish eating all the food on one's plate or on the table; "She polished off the remaining potatoes")
  => devour#3, down#2, consume#1, go through#4  -- (eat immoderately; "Some people can down a pound of meat in the course of one meal")
  => fill up#4, fill#7  -- (eat until one is sated; "He filled up on turkey")
Example

Lexical Units (LU):


perl bfs3.perl eat#v#2 breakfast#v#1

Found at distance 1 (14 nodes explored)

breakfast#v#1 hypo eat#v#2
Lexical Units (LU):
breakfast.v, consume.v, devour.v, dine.v, down.v, drink.v, eat.v, feast.v, feed.v, gobble.v, gulp.n, gulp.v, Guzzle.v, have.v, imbibe.v, ingest.v, lap.v, lunch.v, munch.v, nibble.v, nosh.v, nurse.v, put away.v, put back.v, quaff.v, sip.n, sip.v, slurp.n, slurp.v, snack.v, sup.v, swig.n, swig.v, swill.v, tuck.v

- perl bfs3.perl eat#v#1 munch#v#1
- Found at distance 2 (101 nodes explored)
- crunch#v#3 hypo chew#v#1 enta eat#v#1

- perl bfs3.perl eat#v#2 munch#v#1
- Found at distance 3 (369 nodes explored)
- crunch#v#3 hypo chew#v#1 enta eat#v#1 hypo eat#v#2
Example

Sense 2

**eat**#2  -- (eat a meal; take a meal; "We did not eat until 10 P.M. because there were so many phone calls"; "I didn’t eat yet, so I gladly accept your invitation")
  => take out#12, take away#5  -- (buy and consume food from a restaurant or establishment that sells prepared food; "We’ll take out pizza, since I am too tired to cook")
  => victual#3  -- (take in nourishment)
  => eat in#1, dine in#1  -- (eat at home)
  => eat out#1, dine out#1  -- (eat at a restaurant or at somebody else’s home)
  => dine#1  -- (have supper; eat dinner; "We often dine with friends in this restaurant")
  => picnic#1  -- (eat alfresco, in the open air; "We picnicked near the lake on this gorgeous Sunday")
  => eat#1  -- (take in solid food; "She was eating a banana"; "What did you eat for dinner last night?")
  => break bread#1  -- (have a meal, usually with company; "The early Christian disciples broke bread together")
  => nosh#1, snack#1  -- (eat a snack; eat lightly; "She never loses weight because she snacks between meals")
  => mess#1  -- (eat in a mess hall)
  => lunch#1  -- (take the midday meal; "At what time are you lunching?")
  => brunch#1  -- (eat a meal in the late morning; "We brunch in Sundays")
  => breakfast#1  -- (eat an early morning meal; "We breakfast at seven")
  => feast#1, banquet#2, junket#3  -- (partake in a feast or banquet)
  => gorge#1, ingurgitate#1, overindulge#1, glut#1, englut#1, stuff#4, engorge#1, overgorge#1, overeat#1, gormandise#1, gormandise#1, gourmandize#1, binge#1, pig out#1, satiate#2, scarf out#1  -- (overeat or eat immodestly; make a pig of oneself; "She stuffed herself at the dinner"; "The kids binged on ice cream")
Digression

• Generative capacity of (natural) language ...
Chomsky Hierarchy

- Formal language theory [Chomsky, 1956]

Recursively enumerable (r.e.) languages

Context-sensitive languages

Context-free languages

Finite state languages
Chomsky Hierarchy

• grammar vs. machine characterization
  – $A \rightarrow aB$, $A \rightarrow a$
  – equivalent to a directed finite network of states and transitions

S $\rightarrow$ aB
B $\rightarrow$ bC
C $\rightarrow$ cD
D $\rightarrow$ dE
E $\rightarrow$ eF
F $\rightarrow$ fG
G $\rightarrow$ g
G $\rightarrow$ aH
H $\rightarrow$ bC
I $\rightarrow$ bC

Birdsong: Bengalese finch song
[Berwick et al., 2011]

Finite state languages
Some useful notions

- Mathematical notion of a language as a set of strings
  \[ L(\text{Bengalese finch song}) = \{abcdefg, abcdeabcdefg, abcdefgabcdefg, \ldots \} \]

- Discrete infinity
  - “A fsm is the simplest type of grammar which, with a finite amount of apparatus, can generate an infinite number of sentences.”

Birdsong: Bengalese finch song [Berwick et al., 2011]
Discussion

• Finite state machine simply encodes **precedence** relations between elements of the string

• The (regular) grammar characterization adds in (possibly unintended) **hierarchical** relations between elements

---

Birdsong: *Bengalese finch song* [Berwick et al., 2011]

```
S → aB
B → bC
C → cD
D → dE
E → eF
F → fG
G → g
G → aH
H → bC
F → aI
I → bC
```
Chomsky Hierarchy

• grammar vs. machine characterization
  – $A \rightarrow aB$, $A \rightarrow a$
  – equivalent to a directed finite network of states and transitions

• English is **not** a finite state language [(9) pg.21, Chomsky, 1955]

• (11)
  (i) If $S_1$, then $S_2$
      *If $S_1$, or $S_2$
  (ii) Either $S_3$, or $S_4$
      *Either $S_3$, then $S_4$

  “there are processes of sentence formation that fsm are intrinsically unable to handle.” [pg23, Chomsky, 1955]

Context-free rules:
  $S \rightarrow$ if $S$, then $S$
  $S \rightarrow$ either $S$, or $S$
  or a **pushdown automaton**
  (= fsm + stack)
Discussion (contd.)

• Grammatical construction
  – If .., then
  – Either .., or
  – “A grammatical construction is a syntactic template that is paired with conventionalized semantic and pragmatic content” [Wikipedia]

In some modern linguistic theories, constructions have little or no distinguished theoretical status
Chomsky Hierarchy

- English is not a context-free language [Higginbotham, 1984]
  - the woman such that (the man such that the man such that) she (gave this to him gave him to this) left is here

Construction: relative clause + extra dependencies
Discussion (contd.)

“if a grammar does not have recursive devices (e.g. loops in fsm) it will be prohibitively complex. If it does have recursive devices of some sort, it will produced infinitely many sentences.” [pg24, Chomsky, 1995]

• Suppose human language is generated by some form of a recursive device:
  – human language admits infinitely many sentences
  – sentences can be arbitrarily long in principle
    (practical limitations on utterance length, working memory etc.)

*Commonsense notion of grammaticality becomes a bit fuzzy*
Chomsky Hierarchy (Fine Grained)

- Crossing dependencies (found in Dutch and Swiss-German)
  
  ... dat Wim Jan Marie de kinderen zag helpen leren zwemmen
  ... that Wim Jan Marie the children saw help teach swim

  ‘... that Wim saw Jan help Marie teach the children to swim’

(figures taken from [Kallmeyer, 2005])

Tree-adjoining Grammar (TAG) [Joshi]
Linear Indexed Grammar [Gazdar]
Combinatory Categorial Grammar [Steedman]
Chomsky Hierarchy (Fine Grained)

Indexed grammars
- Context-free languages
  - if-S-then-S
  - either-S-or-S
- Finite state languages
- Mildly context-sensitive languages (linear indexed grammars)
  - Birdsong
  - Crossing dependencies

Computational advantage: polynomial time parsable
Primate language

• Northern muriquis

• Group studied extensively since 1982

• Data collected
  – 212 sequential exchanges vocalizations, emitted by several members:
    – 10 adult males (n=80),
    – 1 sub adult male (n=1),
    – 17 adult females (n=122), and
    – 2 sub adult females (n=3)
  – **sequential exchange** = vocalization of an individual and the response of different group members
  – Muriqui vocalizations have a quite long duration allowing to analyze them as sequences of different elements that are repeated or varied over time
  – It is possible to identify subparts in vocalizations that we designate by the term ‘segmental’ units
Primate language

• Sample utterance
Primate language

- Sequence:
  - \( tp \, tpp \, .. \, tpp .. p \, Gt \)
  (monotonically increasing \# p's)

**Indexed grammars**

- Arithmetic progression sequences
- String containing an arithmetic progression
- Mildly context-sensitive languages (linear indexed grammars)
- Finite state languages
- Context-free languages
- if-S-then-S
  - either-S-or-S
- Birdsong
- Crossing dependencies

---

Indexed grammars

Mildly context-sensitive languages

Finite state languages

Context-free languages

if-S-then-S

either-S-or-S

Birdsong

Crossing dependencies

String containing an arithmetic progression

- \( tp \, tpp \, .. \, tpp .. p \, Gt \)
Primate language

• Sequence:
  – tp tpp .. tpp..p Gt
    (arithmetic progression)

• Indexed grammar [Aho, 1967]
  – equivalent to nested stack automaton
    – S[..] → K[p..] Gt
    – K[..] → tP[..] K[p..]
    – K[..] → tP[..]
    – P[p..] → pP[..]
    – P[] → []

Example derivation:
=> tp K[pp] Gt => tp tP[pp]
K[ppp] Gt => tp tpp K[ppp] Gt =>
 tp tpp tP[ppp] K[pppp] Gt => tp
 tpp tppp tP[pppp] Gt => tp tpp
 tppp tpppp Gt

Each non-terminal has individual stack copy
Primate language

- Sequence:
  - tp tpp .. tpp..p Gt
  (arithmetic progression)

Intuition:
indexed grammar with binary branching
1\textsuperscript{st} nonterminal generates \( k \) p’s, and
2\textsuperscript{nd} nonterminal recursively generates sequences involving \( k+1 \) p’s

- Rely on a crucial distinction between \textbf{Indexed grammars} (IG) and the strictly smaller class of \textbf{Linear indexed grammars} (LIG)
  - at most one nonterminal in each production be specified as receiving the stack, whereas in a normal indexed grammar, all nonterminals receive copies of the stack

- [Vijay-Shanker and Weir, 1994] demonstrated that LIG, CCG, TAG are all (weakly) equivalent formalisms = “Mildly Context-Sensitive Languages”
Indexed grammars

Context-sensitive languages

Context-free languages
- if-S-then-S
- either-S-or-S

Finite state languages

Mildly context-sensitive languages
(linear indexed grammars)

Chomsky Hierarchy (Fine Grained)

Computational disadvantage: not polynomial time parsable

Arithmetic progression sequences

Birdsong

Crossing dependencies
Discussion (contd.)

• Possible objection
  – did I pick out a hard subset of an easy language?

for example, a subset of a finite state language is not necessarily a finite state language
Discussion (contd.)

- **Data**

<table>
<thead>
<tr>
<th>Code</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>AR 16</td>
<td>r r r r p r p r p r p r p r p</td>
</tr>
<tr>
<td>BL 01</td>
<td>p r p r p r p r p r p r p r p p</td>
</tr>
<tr>
<td>BL 06</td>
<td>t t t r p h p h p p r p p r p p r R R</td>
</tr>
<tr>
<td>BS 07</td>
<td>t t t p r p r p r p r p r p p</td>
</tr>
<tr>
<td>BS 16</td>
<td>t p p p p r p r p p G R R R R R R</td>
</tr>
<tr>
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<td>t r r h r r R p p R</td>
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<td>t r p r p p r p r p</td>
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<td>NL 02</td>
<td>p r p h p p p R p R A A</td>
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<tr>
<td>ZO 08</td>
<td>t r r h h h h p p p p p p R</td>
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*what counts as a “construction” here?*
Discussion (contd.)

• Weak generative capacity:
  – rely on surface string patterning only

<table>
<thead>
<tr>
<th>Rule</th>
<th>Non-terminal</th>
<th>and Terminal</th>
<th>Symbols</th>
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<td>S[..] → K[p..] Gt</td>
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<td>K[..] → tP[..] K[p..]</td>
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<td>P[] → []</td>
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</table>

• No intuition about the “constituents” of muriqui language
Finite state languages
Context-free languages
Mildly context-sensitive languages (linear indexed grammars)

Indexed grammars

if-S-then-S
either-S-or-S

Human Languages
Context-sensitive languages