

# The Matrix: Future Directions

## Wrap up

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Ling 567

March 5, 2024

# Overview

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- Wrap up/reflections
- Matrix: Future directions
- AGGREGATION

# Goals: Of Grammar Engineering

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- Build useful, usable resources
- Test linguistic hypotheses
- Represent grammaticality/minimize ambiguity
- Build modular systems: maintenance, reuse

# Goals: Of this course

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- Mastery of tfs formalism
- Hands-on experience with grammar engineering
- A different perspective on natural language syntax
- Practice building (and debugging!) extensible system
- Contribute to on-going research in multilingual grammar engineering

# Reflections (break-out)

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- Where have the analyses provided by the Matrix (or suggested by the labs) seemed like a good fit?
- Where have they been awkward?
- What have you learned in this class about syntax?
  - ... about knowledge engineering for NLP?
  - ... about computational linguistics in general?
  - ... about linguistics in general?
- What did you learn about similarities and differences across languages?

# Feedback: projects

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- Was the workload reasonable?
- What helped in making it (more) manageable?
- How did you handle sharing the workload?
- What would have been better about working alone?

# More reflections

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- Semantic representations are important
  - It's easier to work on them if they serve as an interface to something
- Analyses of phenomena interact
  - The more streamlined/motivated the analysis of each phenomenon is, the smoother the interactions
  - What interactions did you encounter?

# More reflections: model and modeling domain

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- From 566: Distinction between the model (HPSG grammar fragment) and the modeling domain (there: English).
- How did this play out in 567?



# Future directions overview

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- More libraries (and semantic harmonization)
- How this class might evolve
- AGGREGATION

# More libraries

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- Next up?
  - Serial verb constructions
  - Pronouns, demonstratives, COG-ST (definiteness)
  - Other non-verbal predicates
  - Other intersective modifiers
  - Numeral classifiers
  - More verb subcategorization
  - Information structure in wh questions & free word order languages
  - Other?
- Also, lots of bugs need fixing :) <https://github.com/delph-in/matrix/projects/1>

# Creating a library for the customization system

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- Choose phenomenon
- Review typological literature on phenomenon
- Refine definition of phenomenon
- Conceptualize range of variation within phenomenon
- Review HPSG (& broader syntactic) literature on phenomenon
- Pin down target MRSs
- Develop HPSG analyses for each variant
- Implement analyses in tdl
- Develop questionnaire
- Extend python backend
- Run regression tests
- Test with pseudo-languages
- Test with illustrative languages
- Test with held-out languages
- Add tests to regression tests
- Add to MatrixDoc pages

# How to evaluate a library

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- Pseudo-languages
- Illustrative languages
- Held-out languages
- Test suites
- Choices files
- Error analysis

# More libraries/reflection from current class

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- What do you most wish was available in the customization system, based on what came up in your test suite?
- In your test corpus?

# Evolution of 567

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- New phenomena: ~~Wh-questions, possessives, while-clauses,~~ relative clauses, ...?
- Ever bigger jump start --- ~~reaching~~ the limit on this one
- Use of inferred choices files from the AGGREGATION project (2019-2023)
- Coverage-driven labs seem most satisfying (MT demo). Is this true? Did you get enough of this this year?

# AGGREGATION Project:

## Motivation & overview

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- Precision grammars are potentially useful for endangered language documentation (Bender et al 2012)
- Field linguists produce extremely rich annotations in the form of interlinear glossed text
- The Grammar Matrix provides a mapping from grammar specifications to precision grammars
- Can we infer sufficiently accurate and complete grammar specifications from IGT?

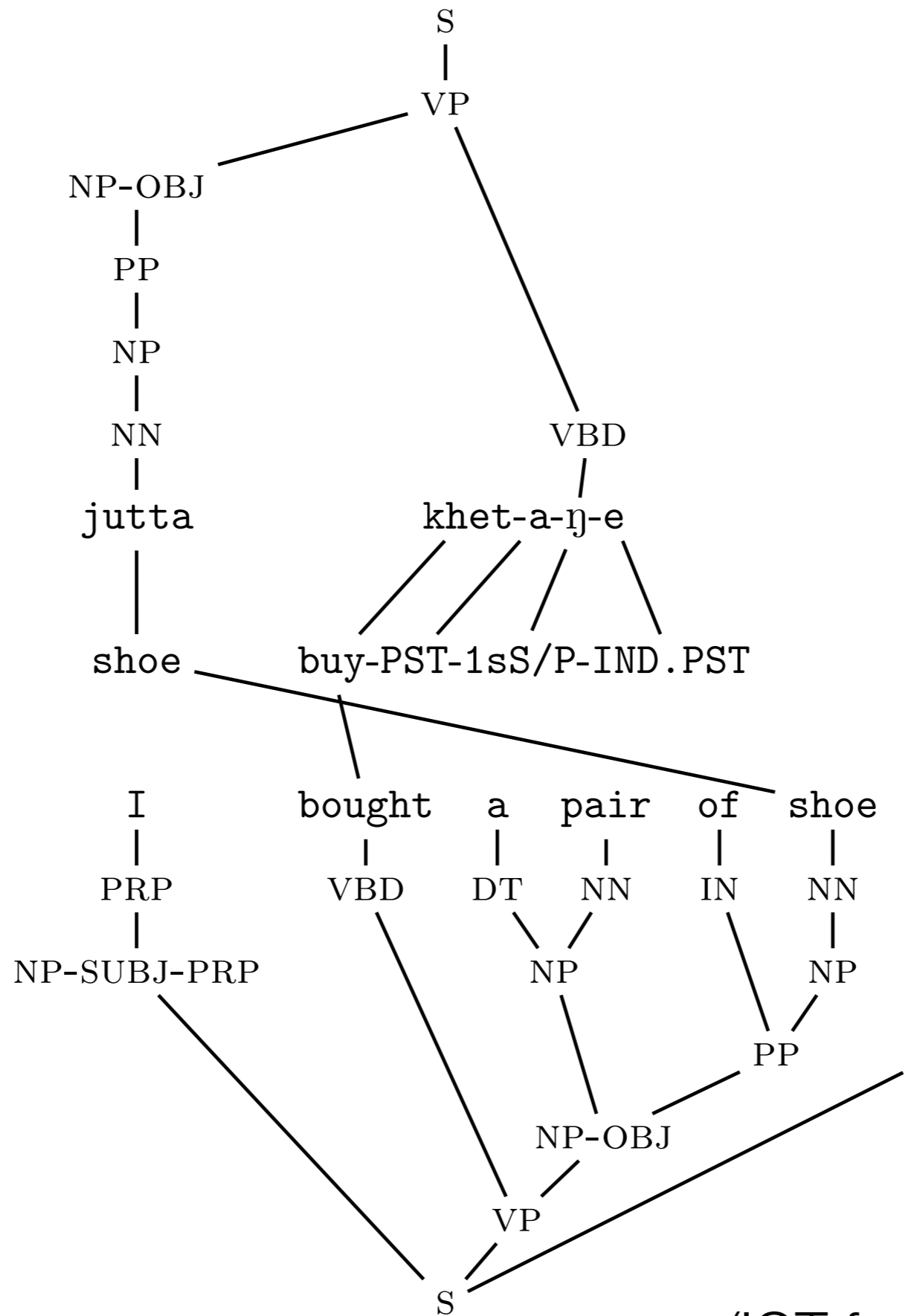
# RiPLEs: Leveraging IGT (Xia & Lewis 2007, Lewis & Xia 2008, Xia & Lewis 2009, Georgi 2016)

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- Interlinear glossed text (IGT) is an extremely rich data type
- IGT exists in plentiful quantities on the web, even for low resource languages
- Example from Chintang [ctn]:

akka ita      khurehẽ





(IGT from Bickel et al 2012)

# Bender et al 2013: Inferring large-scale properties

## Task 1: Major constituent word order

- Count word order patterns in projected trees
- Calculate ratios of OS:SO etc
- Plot points for each language in 3D space
- Compare to hypothesized canonical points for each word order
- V2 (and not free) if SVO,OVS >> SOV,OSV

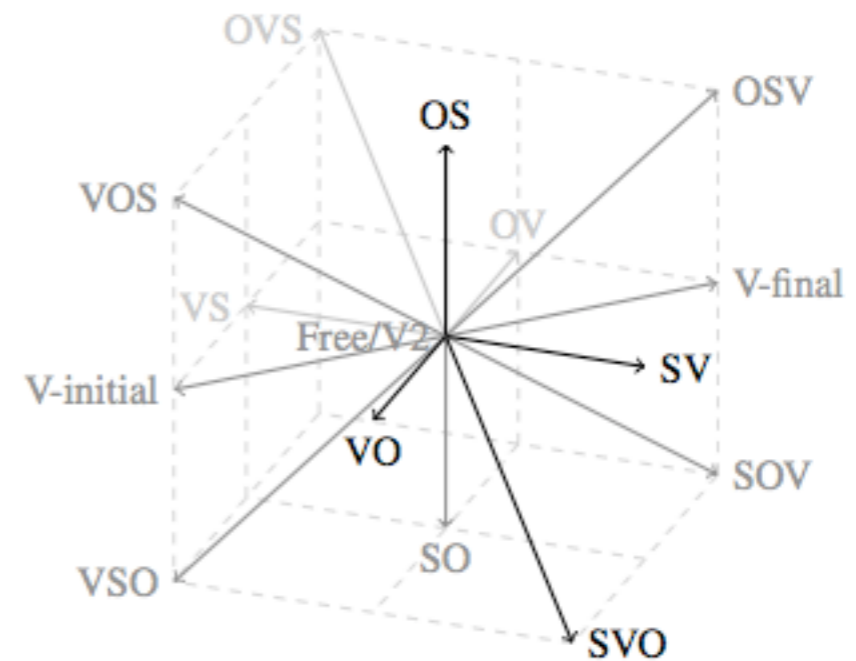


Figure 2: Three axes of basic word order and the positions of canonical word orders.

Dataset	Inferred WO	Baseline
DEV1	0.900	0.200
DEV2	0.500	0.100
TEST	0.727	0.091

Table 2: Accuracy of word-order inference

# Wax 2014, Zamaraeva 2016, Zamaraeva et al 2019: Learning lexicons & morphological systems

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- General parameters like word order alone won't lead to a usable grammar
- Also required: lexicon and morphotactics (and morphophonology...)
  - Create lexical rules for each morpheme, with associated form and morphosyntactic and morphosemantic features
  - Group morphemes into position classes
  - Determine ordering relations
  - Lexicon: part of speech, case frame, argument optionality...

# Lepp et al 2019: Visualizing inferred morphotactics

Search

Cluster by hubsize

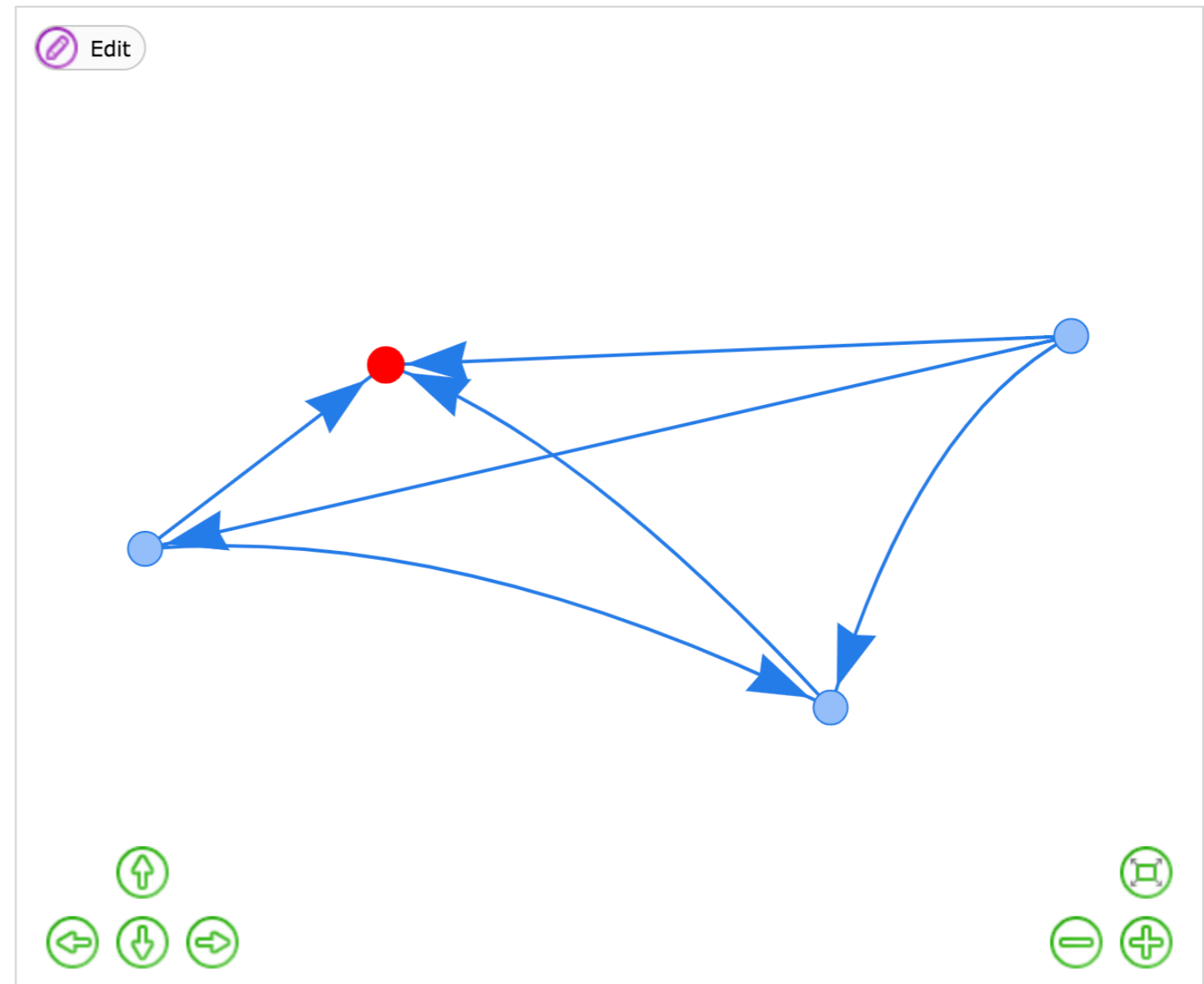
- verb-pc1
- verb-pc3
- suffix
  - PST/-3SG
  - s/-ed
- verb1
- wrap
- work
- wed
- verb-pc2

## MOM Visualization

Choose File eng\_overlap\_graph.dot

Create file

Edit



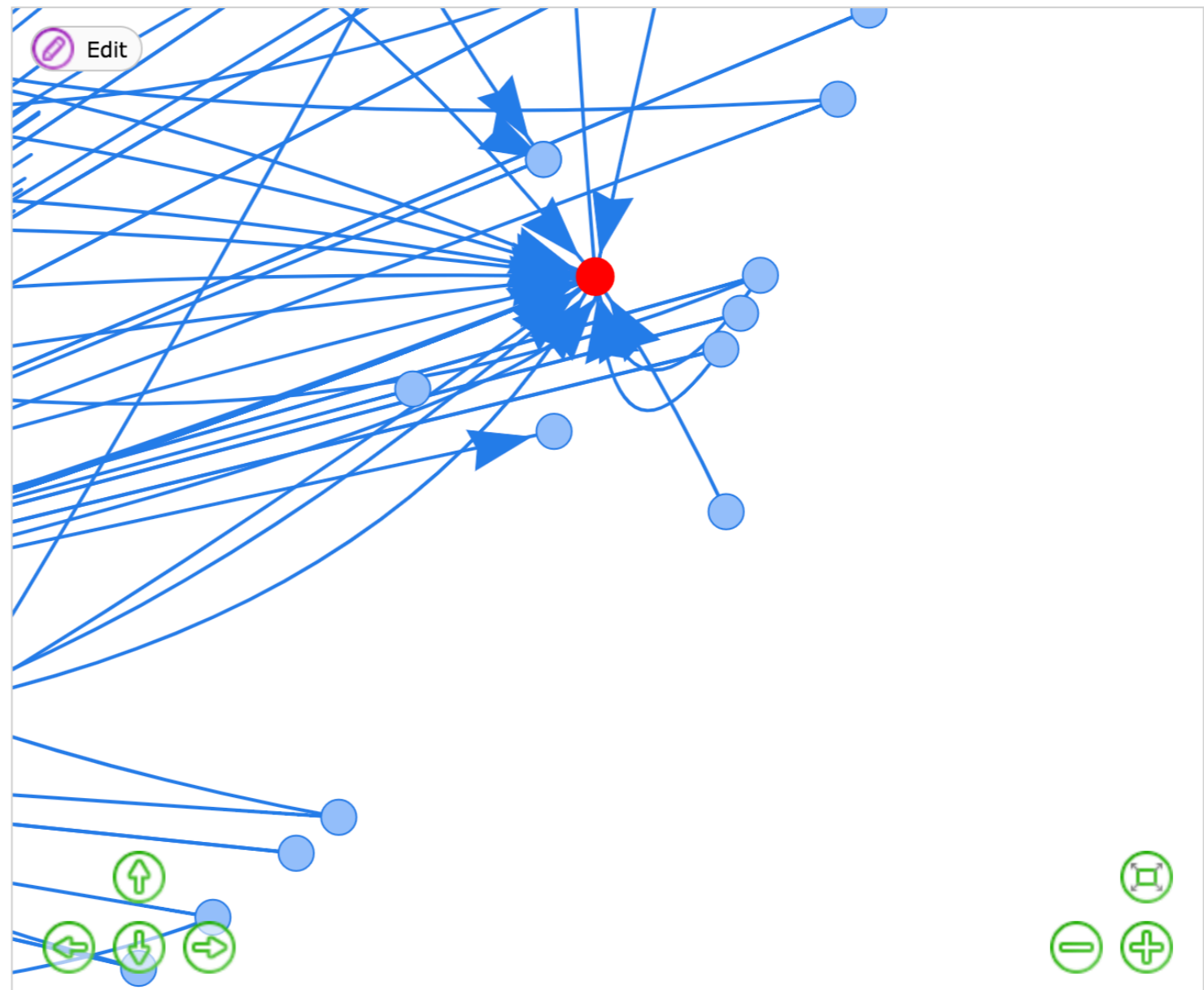
# Lepp et al 2019: Visualizing inferred morphotactics

verb-pc5
verb340
verb436
verb1710
verb-pc54
prefix
Distr.rec-
to-
verb-pc48
verb-pc39
verb30
verb1627
verb247
verb295

## MOM Visualization

Choose File abz\_overlap\_graph.dot

Create file



# End-to-end evaluation with Chintang [ctn] (Zamareva et al 2019)

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Choices file	# verb entries	# noun entries	# verb affixes	# noun affixes
ORACLE	899	4750	233	36
BASELINE	3005	1719	0	0
FF-AUTO-GRAM	739	1724	0	0
MOM-DEFAULT-NONE	1177	1719	262	0
INTEGRATED	911	1755	220	76

Table 3: Amount of lexical information in each choices file

choices file	lexical coverage (%)	parsed (%)	correct (%)	readings
ORACLE	116 (12.5)	20 (2.2)	10 (1.1)	1.35
BASELINE *	38 (0.4)	15 (1.6)	8 (0.9)	27.67
FF-AUTO-GRAM	18 (1.9)	4 (0.4)	2 (0.2)	5.00
MOM-DEFAULT-NONE	39 (4.2)	16 (1.7)	3 (0.3)	10.81
INTEGRATED	105 (11.3)	32 (3.4)	15 (1.6)	91.56

\* We report slightly different results for lexical coverage and average readings for the baseline than [Bender et al. \(2014\)](#) because we removed determiners from the choices file.

Table 4: Results on 930 held-out sentences

# Extending inference: Howell 2020, Conrad 2021, Howell & Bender 2022, Dods 2022, Lin 2023

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- Previously available: major constituent word order, case systems, case frames for verbs, case values for nouns
- Adding: argument optionality, coordination, PNG on nouns and agreeing categories, tense/aspect/mood, sentential negation, adverbial subordinate clauses, adnominal possession, valence changing morphology
- System tested in Ling 567 as starting grammar specifications (noisy!)
- Howell 2020, Howell & Bender 2022: Testing on 14 languages: 5 dev, 4 initial held-out, 5 more held-out
  - Coverage, ambiguity, treebanked accuracy

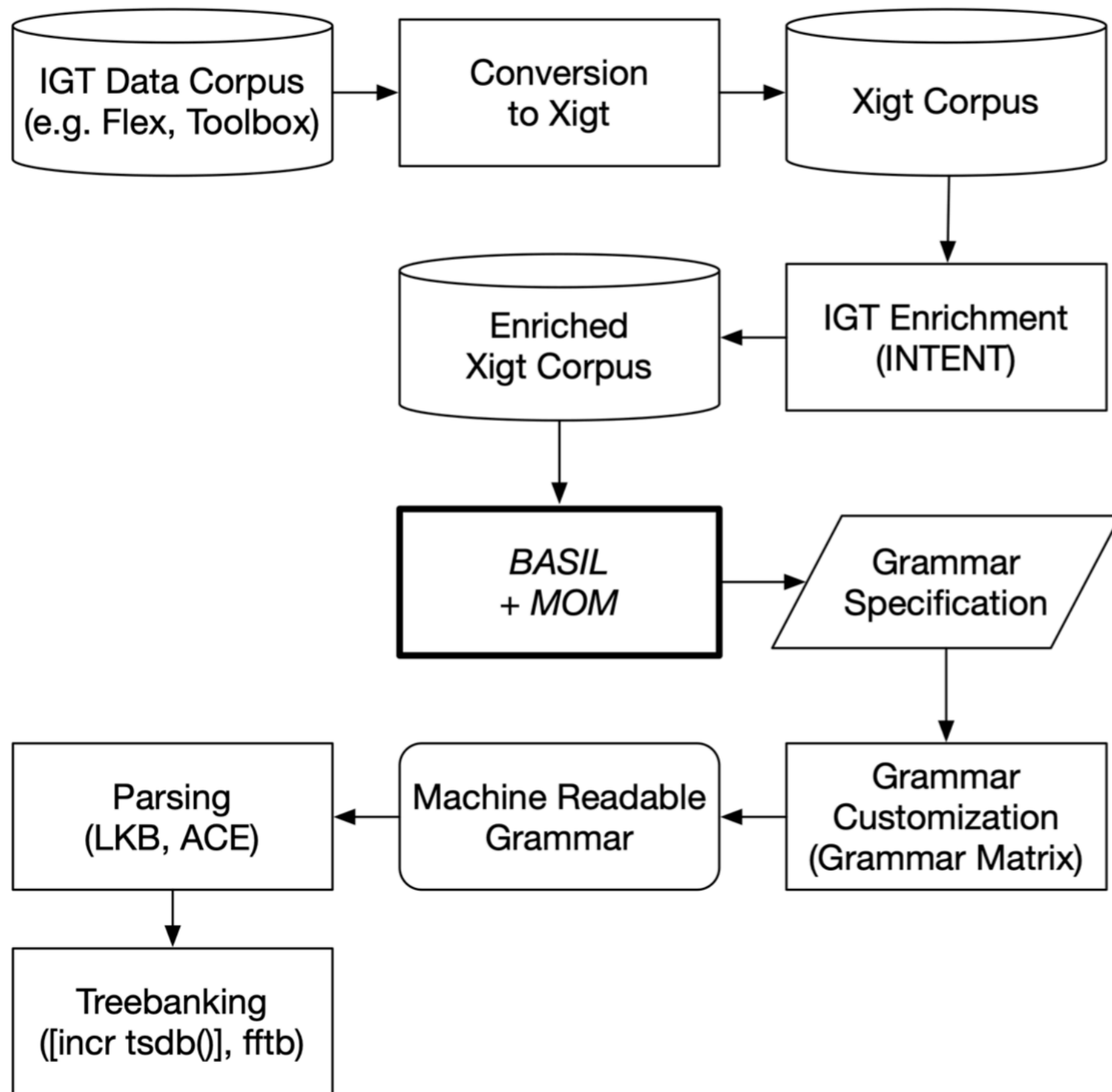
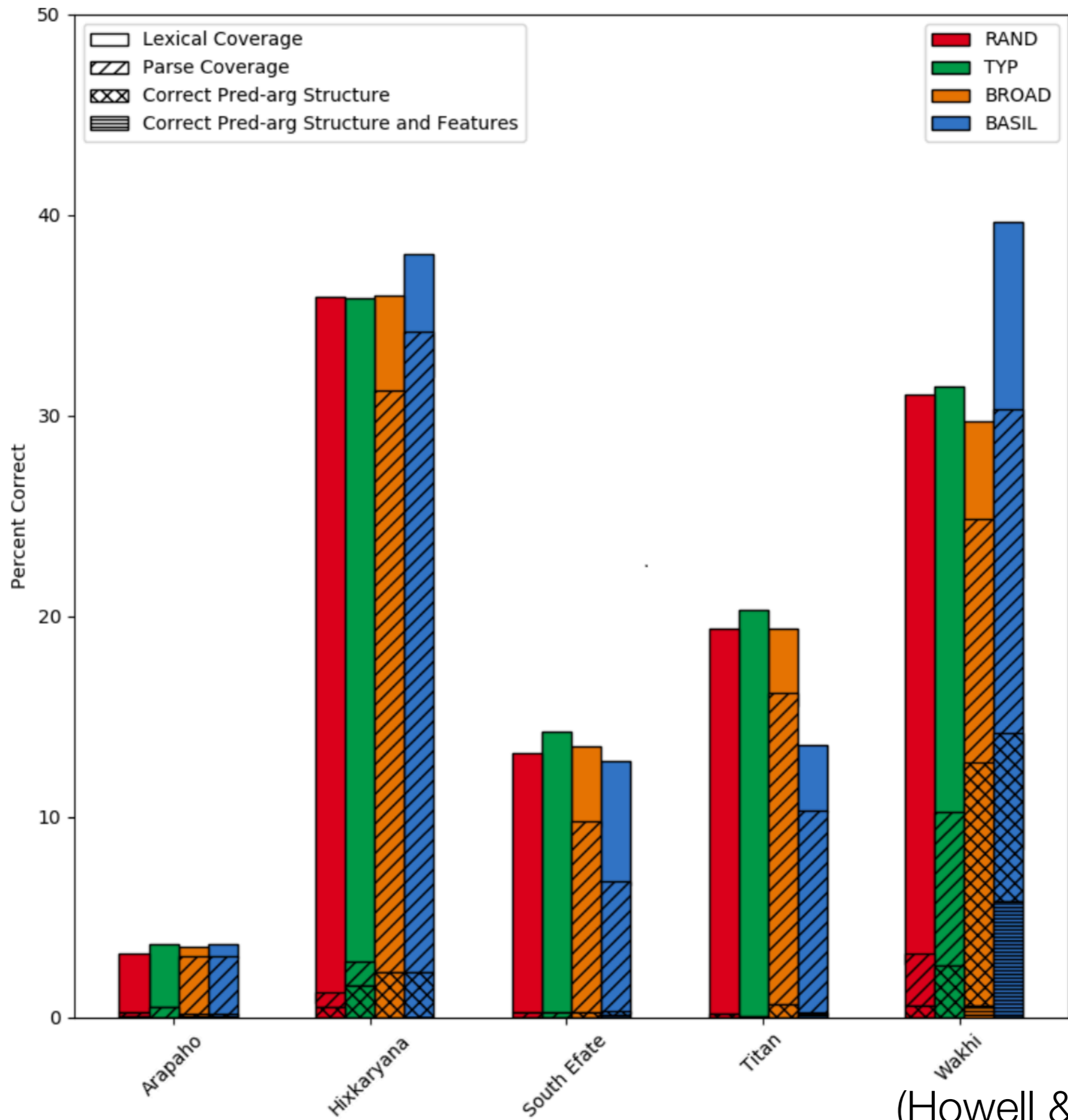


Figure 1: AGGREGATION Pipeline

(Howell & Bender 2022)





(Howell & Bender 2022)

# Overview

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- Wrap up/reflections
- Matrix: Future directions
- Next time: MMT extravaganza and course evals