

Integrated Testing of Typological Hypotheses at Scale

Empirical consequences of universal claims in
grammatical theorizing
Hamburg, Germany

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Absence of Counterevidence: Support for Universals?

- ▶ One way of finding universals is accumulating sets of uncontradicted hypotheses
 - ▶ E.g. as synthesized from typological literature



Absence of Counterevidence: Support for Universals?

- ▶ One way of finding universals is accumulating sets of uncontradicted hypotheses
 - ▶ E.g. as synthesized from typological literature
 - ▶ ...and as supported by continuous study of data



Hypothesize – Encode – Test – Revise

- ▶ Encoding hypotheses *computationally* helps test them **at scale and in interaction** with each other



Linguistic Hypotheses Testing with the Grammar Matrix

- ▶ A meta-grammar engineering system (Bender et al. 2002, 2010) couched in HPSG (Pollard and Sag 1994)
- ▶ Typological breadth + depth of formal syntax
- ▶ Other GE systems: Müller 2015; Butt et al. 2002



Cross-Linguistic Analyses in the Grammar Matrix

- ▶ Web questionnaire for a range of phenomena
 - ▶ Grounded in typological knowledge
 - ▶ Interfacing with HPSG analyses

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- ▶ Set of machine-readable theoretically-grounded* elements
 - ▶ “core” HPSG type hierarchy
 - ▶ (not in the core/periphery sense of Chomsky 1977)

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- ▶ Set of machine-readable theoretically-grounded* elements
 - ▶ “core” HPSG type hierarchy
 - ▶ (not in the core/periphery sense of Chomsky 1977)
- ▶ Logic which customizes core types given specification
 - ▶ E.g. core: basic phrase structure type agnostic to the Subject-Verb relative order
 - ▶ Customized to SV if basic order SVO is specified

*The goal is not to insist on one specific **theory** but to allow for testing of various hypotheses, formal or descriptive, within the HPSG **formalism**

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- ▶ Set of formalized hypotheses about syntax, e.g.:
 - ▶ The semantics of a phrase is compositional
 - ▶ Most phrases have an identifiable head daughter
 - ▶ Heads determine which arguments they require
 - ▶ Modifiers determine which heads they can modify
 - ▶ No rule can remove semantic information
- ▶ Served for 150+ natural language grammars
- ▶ Under continuous development:
 - ▶ As “libraries” for more phenomena are added, parts of the core may be found language-specific and revised



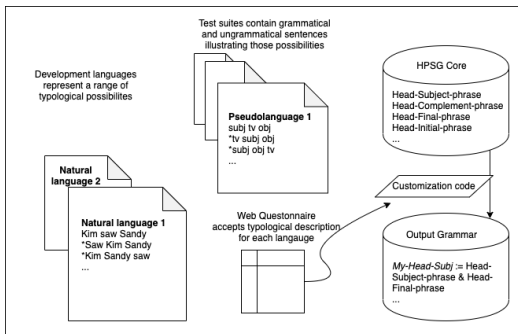
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Test-Driven Development for the Grammar Matrix

- ▶ Methodology by Oepen and Flickinger 1998; Bender et al. 2010
- ▶ Develop and revise analyses based on grammar performance over typologically informed test suites



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Regression Testing of Customization System

Any change to the system is tested for compatibility with all the languages which have been modeled in the process of system development (50+ real, 400+ artificial).

| | |
|---------------------------------|------|
| valchg-subj-rem-osv | PASS |
| valchg-subj-rem-sov | PASS |
| view-inf-situ-inher | PASS |
| view-situ-aspect-infl | PASS |
| vos-aux-after-vp | PASS |
| vos-aux-before-vp | PASS |
| vos-vp-aux-case-raais | PASS |
| vso-aux-after-v | PASS |
| vso-aux-before-v-cluster | PASS |
| vso-aux-before-v-no-cluster | PASS |
| vso-aux-before-vp | PASS |
| wh-svo-sg-oblig-min | PASS |
| wh10-svo-multi-all-oblig-min | PASS |
| wh11-svo-multi-one-oblig | PASS |
| wh2-sov-sg-oblig-min | PASS |
| wh3-vso-sg-oblig-det | PASS |
| wh4-free-sg-oblig-min | PASS |
| wh5-free-sg-oblig-det | PASS |
| wh6-svo-sg-opt | PASS |
| wh7-sov-sg-opt | PASS |
| wh8-ovs-insitu | PASS |
| wh9-vos-sg-oblig-ppip-all-oblig | PASS |

```
***** SUMMARY *****  
Passed 473/488 tests;  
Failed 9/488 tests;  
Errors 6/488 tests.
```

The more languages we accumulate in the regression testing system, the more evidence we have that the analyses are valid

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Error Analysis over Grammar Matrix Library Projects

Three (3) cases of a typological generalization being contradicted by an evaluation language

- ▶ Coordination (Drellishak and Bender 2005)
 - ▶ Generalization: Coordinators occur before or after one or multiple coordinands
 - ▶ West Greenlandic: Second position clitic in the conjunct

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 - ▶ West Greenlandic: Second position clitic in the conjunct
- ▶ Clausal complementation (Zamaraeva et al. 2019)
 - ▶ Generalization: An entire complement is usually extraposed
 - ▶ Jalkunan: *In situ* pronoun along with extraposition

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 - ▶ Generalization: An entire complement is usually extraposed
 - ▶ Jalkunan: *In situ* pronoun along with extraposition
- ▶ Clausal modifiers (Howell and Zamaraeva 2018)
 - ▶ Generalization: Temporal clausal modifiers tend to attach at VP/S level
 - ▶ Ma'di: Adverb subordinators may intervene between the verb and object, suggesting low (V) attachment

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The Grammar Matrix Validation Code

- ▶ Main purpose: Ensure the system outputs grammars which can be successfully loaded into parsing software (LKB; Copestake 2002)
- ▶ Focus on technical validity of specification
 - ▶ E.g. if specified a determiner, must specify determiner-noun order

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- ▶ Focus on technical validity of specification
 - ▶ E.g. if specified a determiner, must specify determiner-noun order
- ▶ Typological validity also included
 - ▶ We are forced to consider (ideally, all) combinations of choices
 - ▶ Clues that a combination is typologically unlikely:
 - ▶ Not mentioned in typological literature
 - ▶ Difficult to implement in HPSG
 - ▶ Having both clues is reassuring

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Grammar Matrix Validation:

Some choices unlikely to combine

You don't need to read all of this!

Is the free subordinator morpheme treated as the head of its clause or as and adverbial?:

- ☐ it is the head of the subordinate clause
- ☒ it is an adverb (not the head of its clause)

If the subordinator is an adverb, does it attach to VP, S or both?

- ☐ VP
- ☐ S
- ☐ Both VP and S

☒ Free Subordinator Morpheme 1:
Spelling: Predicate:

The clausal modifier has the following features

Note: Features can be defined on the Other Features page. If this morphological feature cannot have a FORM feature.

☒ Name: *nominalization Value:

Nominalization is not supported of the adverb analysis.

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Conclusion: The Grammar Matrix Helps Us Test Hypotheses in Interaction

- ▶ Lack of counterexamples can be seen as support for generalizations

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Conclusion: The Grammar Matrix Helps Us Test Hypotheses in Interaction

- ▶ Lack of counterexamples can be seen as support for generalizations
- ▶ The more hypotheses we test in interaction, the stronger evidence we have for their usefulness

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Conclusion: The Grammar Matrix Helps Us Test Hypotheses in Interaction

- ▶ Lack of counterexamples can be seen as support for generalizations
- ▶ The more hypotheses we test in interaction, the stronger evidence we have for their usefulness
- ▶ Over 150 natural languages and over 400 constructed typological combinations modeled with the Matrix
 - ▶ Analyses and tests preserved; results replicable
 - ▶ Support for most “core” generalizations
 - ▶ But: Of course there are biases in the tests!
 - ▶ We sometimes find exceptions to typological generalizations as represented in literature

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- ▶ Over 150 natural languages and over 400 constructed typological combinations modeled with the Matrix
 - ▶ Analyses and tests preserved; results replicable
 - ▶ Support for most “core” generalizations
 - ▶ But: Of course there are biases in the tests!
 - ▶ We sometimes find exceptions to typological generalizations as represented in literature
- ▶ Continuous development
 - ▶ Analyses (including typological categories) can be revised systematically as motivated by new data

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Jalkunan Clausal Complementation

(1) ma n so [[ma je] see]
1Sg 3SgNonhObj know.Pfv [[1Sg father] come.Pgv]
'I know that my father has come.' [bɣl] (Heath 2017)

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Adverbial subordinators in Mandarin

(2) Wǒ yīnwèi hàipa Zhāngsān, méi suǒyǐ chū - qu
1.SG because fear Zhāngsān NEG so go out
'Because I feared Zhāngsān, I did not go out.' [cmn]
(Jiahui Huang, pc.)

(3) to'a- dhaac -ae =li ma-
 REAS.NMZ- DYN.NFIN:leave -REAS.NMZ =1SG.GEN STAT.FIN-
 Irakas -iae
 dislike -1SG.OBL
 'The reason why I'm leaving is because I dislike being
 here' [dru] (Zeitoun 2007)

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Adverbial Subordinator in Ma'di

(4) Le ee=ve-age lai ga oeo-m
day 3SG.ACC=come.out-ANT rain the go.around-3SG.ACC
'Upon the day coming out, the rain soaked him.' [mhi]
(Blackings and Fabb 2003)

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