A Regression of Morphological Differences on an Empirical Measure of Learning Difficulty

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Job Schepens

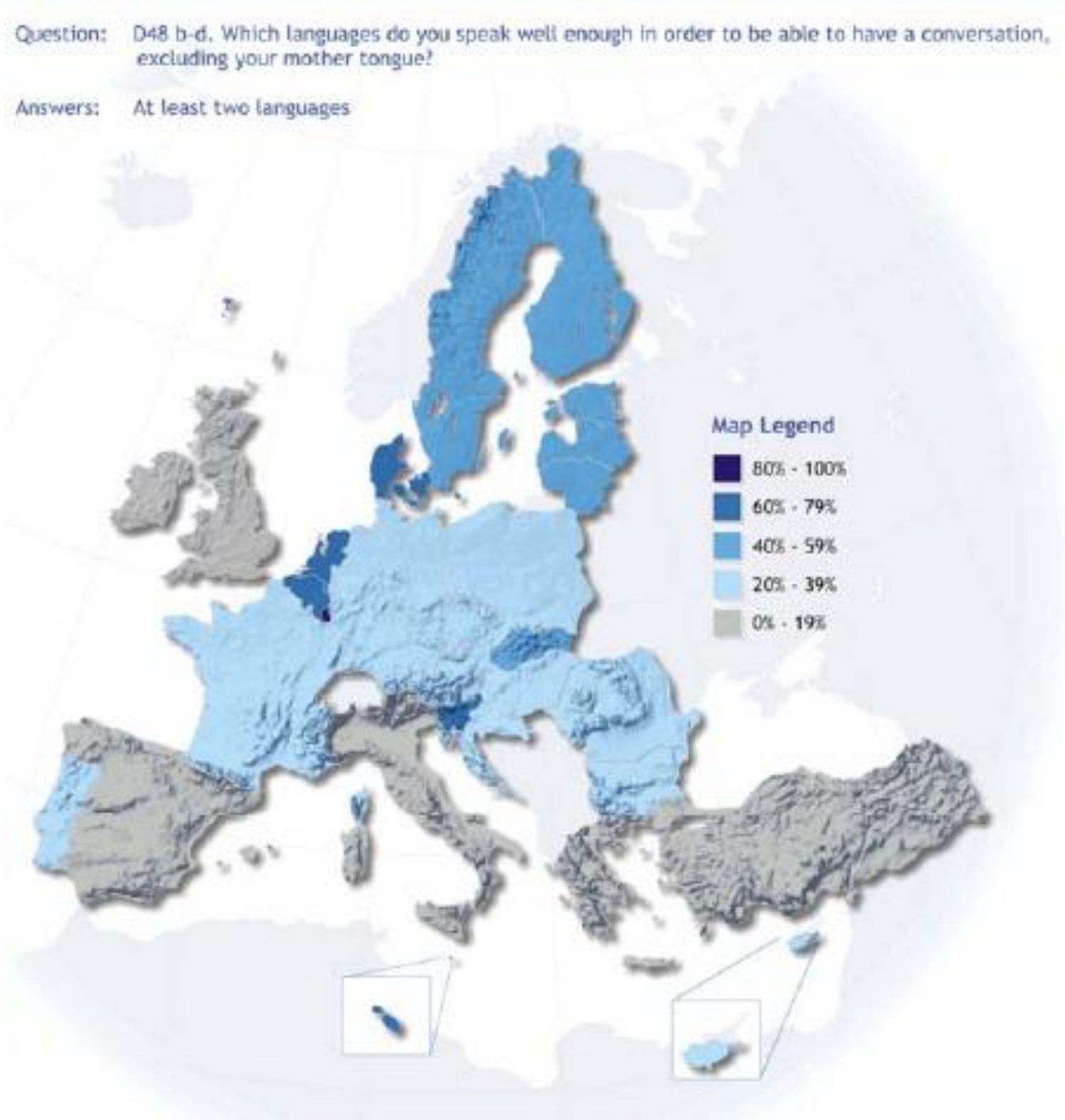
Centre for Language Studies, Radboud University Nijmegen, the Netherlands
International Max Planck Research School for Language Sciences, Nijmegen, the Netherlands

j.schepens@let.ru.nl

Introduction

56% of citizizens in the EU member states are able to have a converstaion in at least one language apart from their mother tongue
(Euro Barometer 243, 2006)

47% 5 years earlier
(Euro Barometer 55.1, 2001)



Introduction

Problem

- It is unclear how the structure of the mother tongue influences the acquisition of an additional language
  - Learning difficulty plays a direct role in language contact situations (accounting for cross-language family tree change)

Aims

- To quantify the impact that various typological feature configurations have on learning difficulty
  - New insights in patterns of borrowing and transfer?
  - New insights in patterns of morphological complexity?
- Bring empirical data of learning difficulty to quantitative diachronic approach

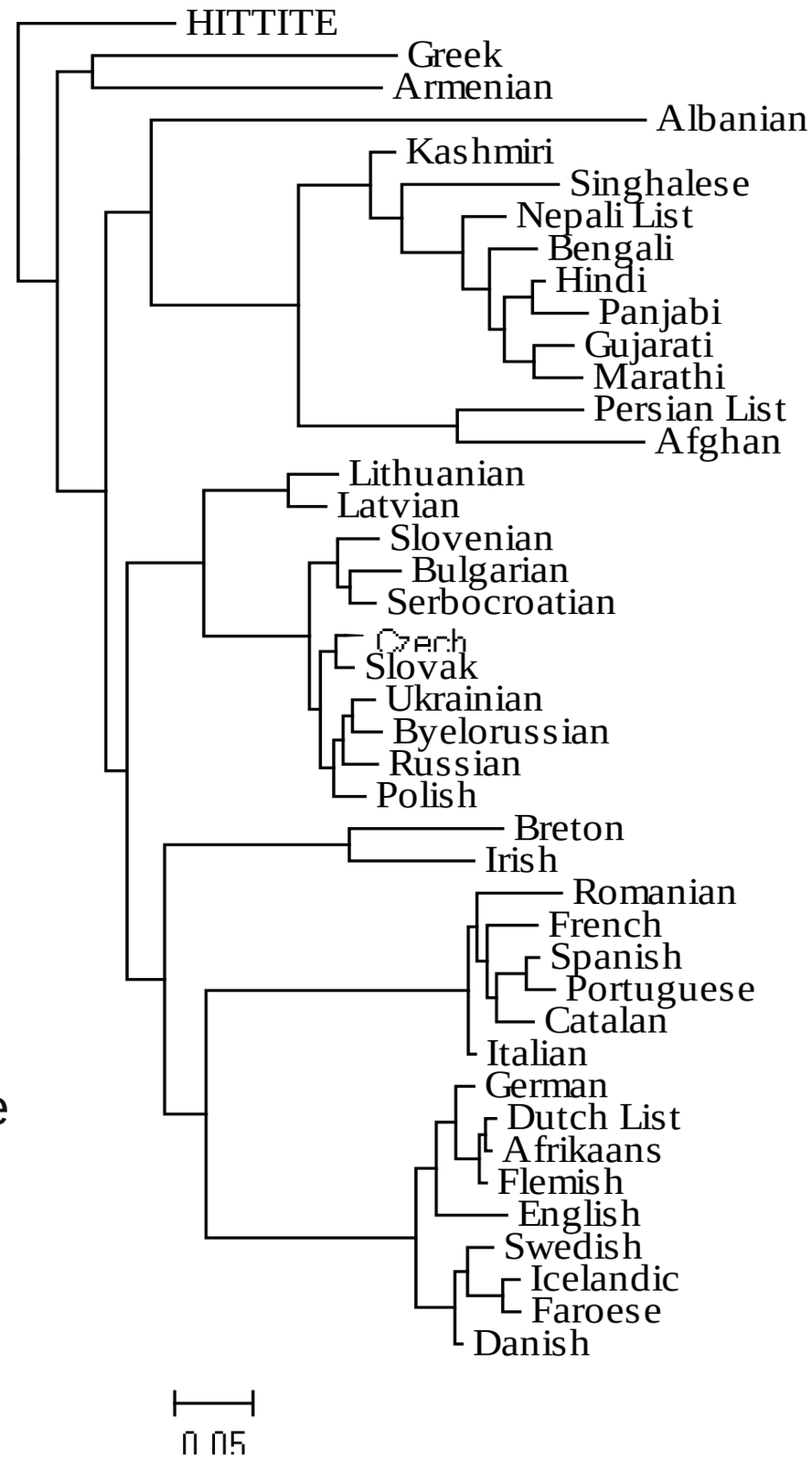
Modelling Linguistic Diversity

- Modelling linguistic diversity helps us understand what we are capable of (Levinson & Gray, 2012)

- Divergence, drift
  - Phylogeny of the Indo European language family on expert cognacy judgments
    - e.g. tomaat (NL), tomato (EN), Tomat (DE)
  - using 200 lexical item lists (Dyen et al. database)

- Founder effect
  - Regression of phoneme inventory size on population size and geographical distance (Atkinson, 2011)
  - using a typological database (WALS) and Ethnologue

- Lexical diffusion and standardization
  - Regression of pronunciation distance on social and geographic factors (Wieling et al, 2011)
  - using a dialect atlas (GTRP) and lexical databases (Celex)

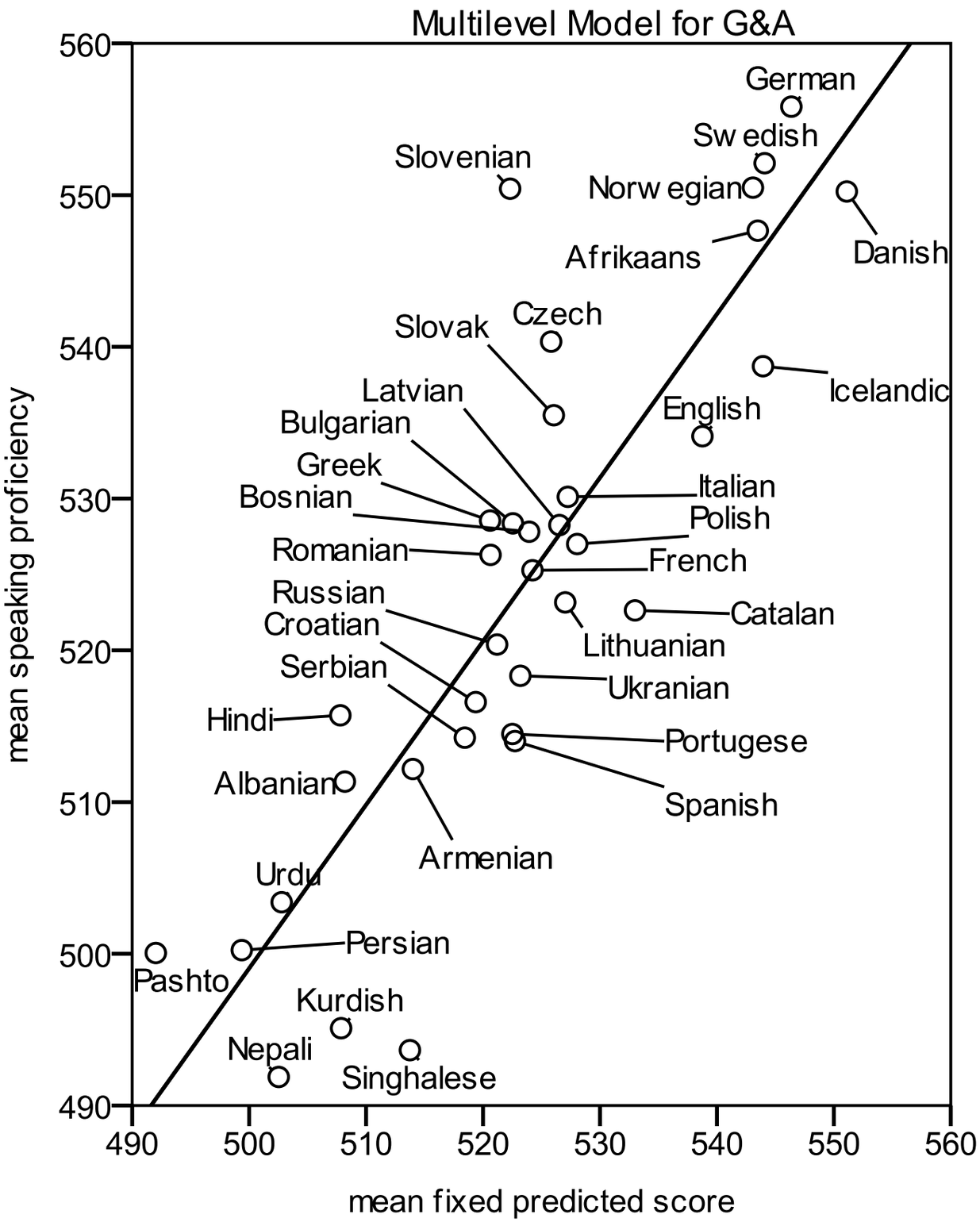


Gray & Atkinson, 2003

Modelling Linguistic Diversity

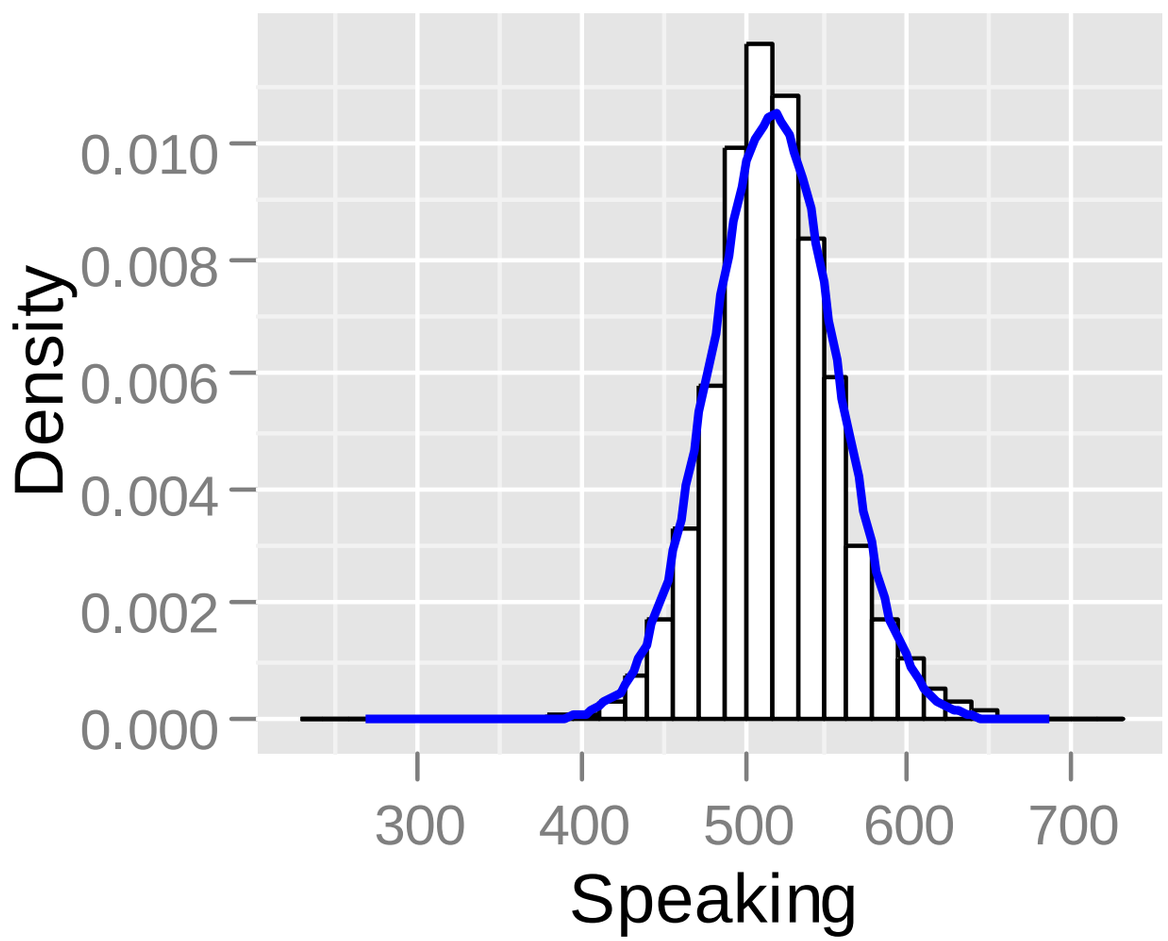
- Adaptation effects? Varying patterns of L2 acquisition across languages?
  - Regression of morphological complexity on the number of speakers of a language (Lupyan & Dale, 2010)
  - using 28 typological features (WALS) and Ethnologue

- Empirical measure of linguistic differences
  - Regression of learning difficulty on measures of evolutionary relatedness (previous study)
  - using branch lengths from Gray & Atkinson (2003)



Learning Difficulty: Data

- State exam “Dutch as a Second Language”
  - Produced by CITO, a Dutch organization that produces tests and exams
  - For non-native speakers who intend to start a higher level education / occupation
  - 1995 – 2010
  - 50,000 test scores available
  - Enough data to test learning differences across 72 mother tongues
- The speaking exam
  - 14 tasks in 30 minutes
    - e.g. provide information, give instructions, …
    - *in Dutch television, a lot of ads are made for all kinds of products, even in the middle of a program. What is your opinion about ads on TV?*
- Evaluation on content and correctness
- Passing level ≈ upper-intermediate / B2 level



Learning Difficulty: Data

- Sample 1
  - 35 Indo-European
    - 35,000 learners
  - 89 countries of birth
- Sample 2
  - 72 mother tongues
    - 50,000 learners

- Fixed Effects
  - Gender, age of arrival, length of residence, years of daily education, educational quality
  - interaction years of daily education and quality
  - interaction age of arrival and linguistic distance
  - interaction length of residence and linguistic distance
  - best additional language
  - linguistic distance

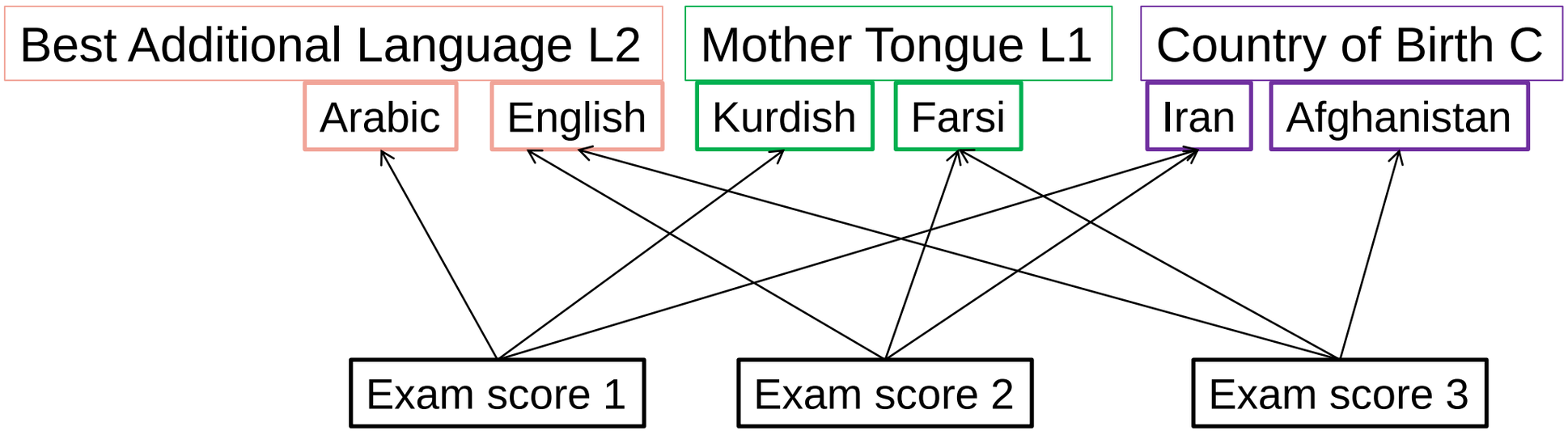
Mother Tongue	Country of Birth	Mean Speaking	Linguistic Distance	Schooling Quality	Group Size
Kurdish	Syria	487	.426	423	63
Kurdish	Turkey	490	.426	454	185
French	Congo	491	.398	350	65
French	France	531	.398	497	936
French	Switzerland	550	.398	517	37
German	Germany	558	.037	510	4434
German	Switzerland	571	.037	517	190

Learning Difficulty: Method

- Linear Mixed Effects Regression
  - Models dependencies in variation by estimating group level BLUPs

- Assumes BLUPs are:
  - normally distributed,
  - centred around 0, and
  - orthogonal to the individual level noise

- Data structure
  - Country of birth (C)
  - Mother tongue (L1)
  - Best additional language (L2)
  - Combinations (L1-L2)



Learning Difficulty: Results (Indo-European only)

Explained Variance
35 languages, 35,000 learners
r = -.77***, N = 35 (correlation observed scores with linguistic distance)
r = .87***, N = 35 (correlation observed scores with fitted scores)

	Learner Std. Dev.	Country of Birth Std. Dev.	Mother Tongue Std. Dev.	Log Likelihood
Null Model	31.27	13.58	11.72	-159,538.0
Multivariate Model	30.59	8.69	5.85	-158,779.7
Relative R^2	4.2%	59.0%	75.1%	758.3

Learning Difficulty: Results (outside Indo-European also)

Model comparison
72 languages, 50,000 learners

Model	Degrees of freedom	Log Likelihood	χ^2	k	Pr(> χ^2)
Null model: L1, C	4	-247,546.18			
L1, C	10	-246,336.19	2,419.98	6	< 2.2e-16 ***
L1L2, C	10	-246,097.03	478.33	0	< 2.2e-16 ***
L1,L2, C	11	-246,003.81	186.43	1	< 2.2e-16 ***
L1,L1L2, C	11	-245,993.14	21.35	0	< 2.2e-16 ***
L1,L2,L1L2, C	12	-245,945.03	96.21	1	< 2.2e-16 ***

Learning Difficulty: Results (outside Indo-European also)

P values and HPD confidence intervals
72 languages, 50,000 learners

Fixed Effects	Estimate	MCMC mean	HPD95 lower	HPD95 upper	Pr(> |t|)
(Intercept)	505.02	504.89	498.44	511.36	< 2.2e-16 ***
1. Gender (1 = Female)	7.39	7.41	6.74	8.05	< 2.2e-16 ***
2. Age of Arrival	-0.72	-0.72	-0.77	-0.68	< 2.2e-16 ***
3. Length of Residence	0.62	0.62	0.55	0.69	< 2.2e-16 ***
4. Years of Daily Education	-0.77	-0.78	-1.83	0.24	0.143
5. Secondary School Enrollment Rate	0.18	0.18	0.11	0.25	< 2.2e-16 ***
6. Interaction 4* 5	0.04	0.04	0.02	0.057	< 2.2e-16 ***

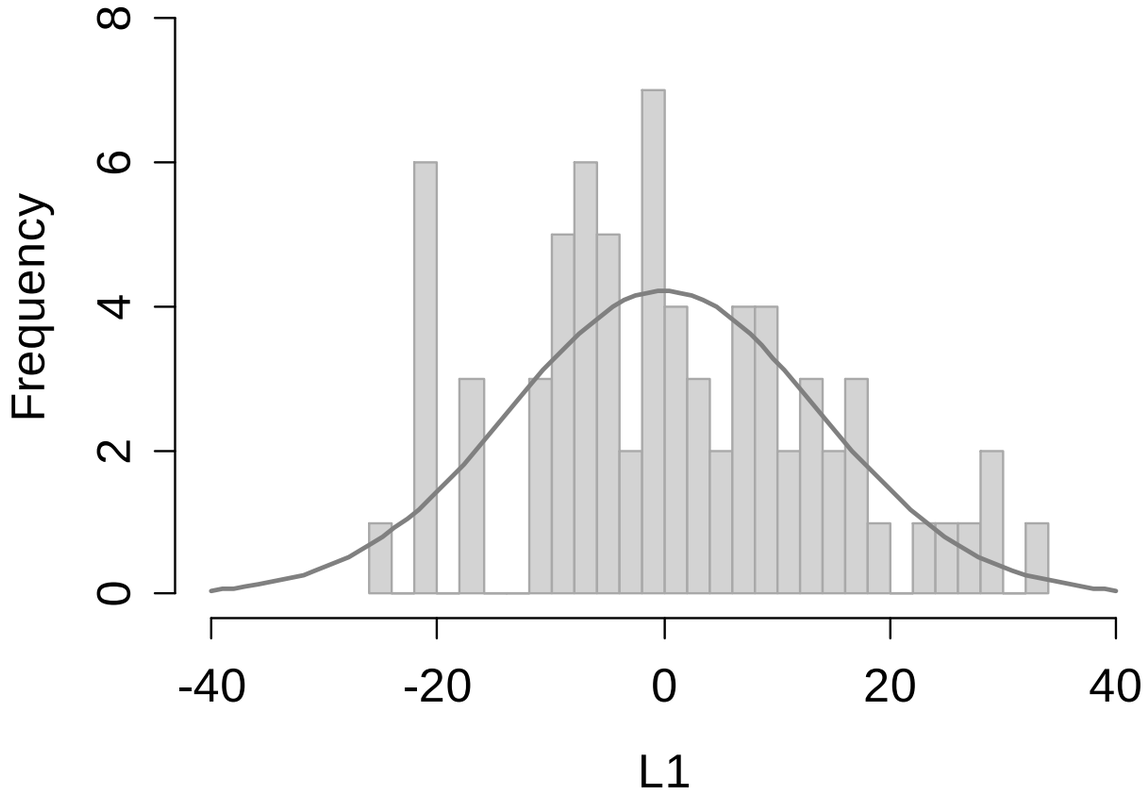
Random Effects	Std. Dev.	MCMC mean	HPD95 lower	HPD95 upper
L1L2	3.29	2.96	2.27	3.70
C	8.30	7.90	6.55	9.26
L1	11.13	10.55	8.76	12.46
L2	3.82	3.93	2.64	5.27
Residual	31.34	31.35	31.16	31.55

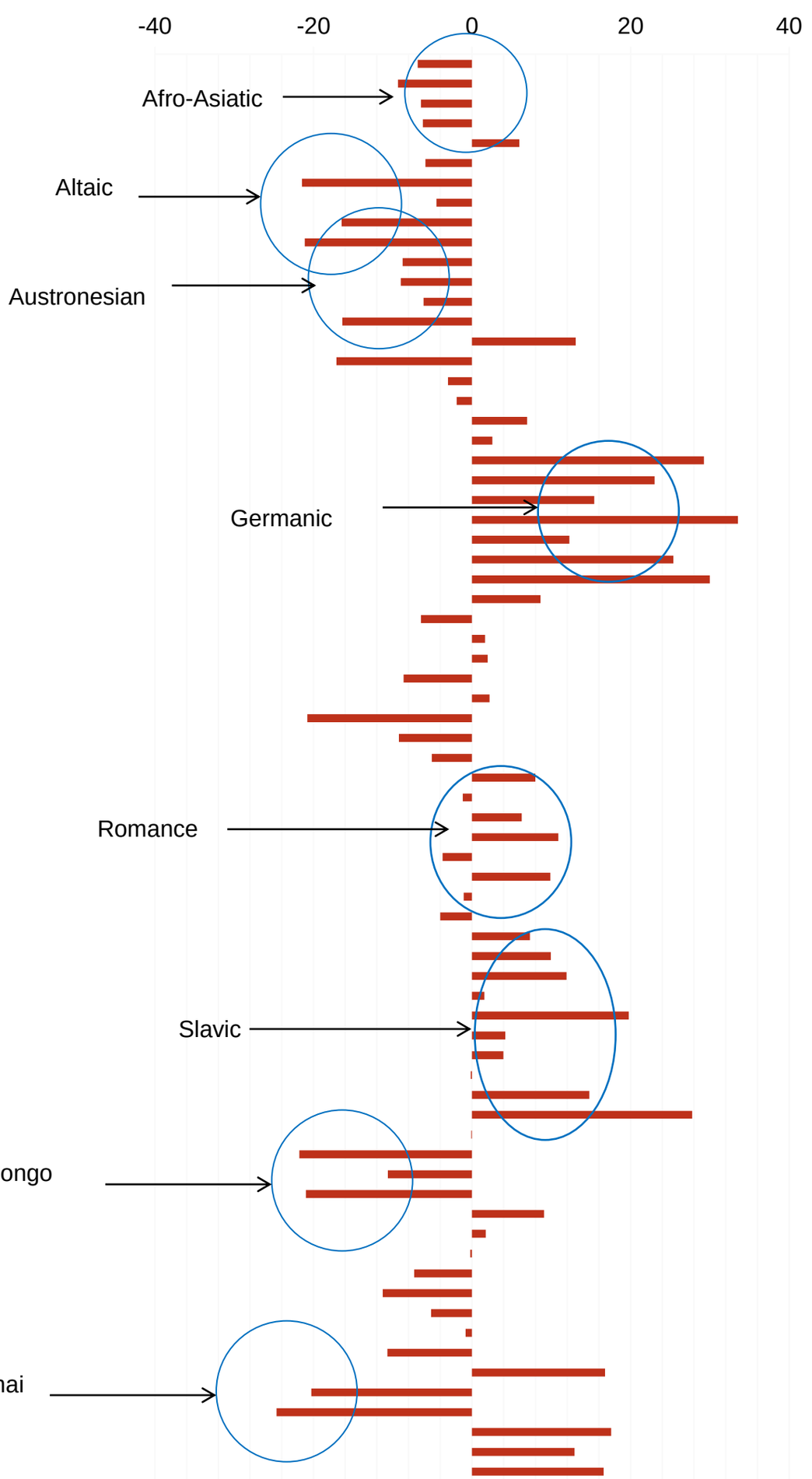
Learning Difficulty: Product

- BLUPs
  - of the random effect of the mother tongue on speaking proficiency in Dutch as an L2

- Account for
  - country characteristics such as educational quality
  - individual differences such as level of education

- Empirical measure of learning difficulty
  - 72 languages, 29 genera, 13 families





Stepwise expanding the analysis

- 1st step
  - **Expose a feature hierarchy** in L2 learnability
  - Regression of differences and overlap in inflectional morphology on learning difficulty

- 2nd Step
  - **Test of adaptation effects:** are complex features more difficult to acquire?

Feature Hierarchy: Data

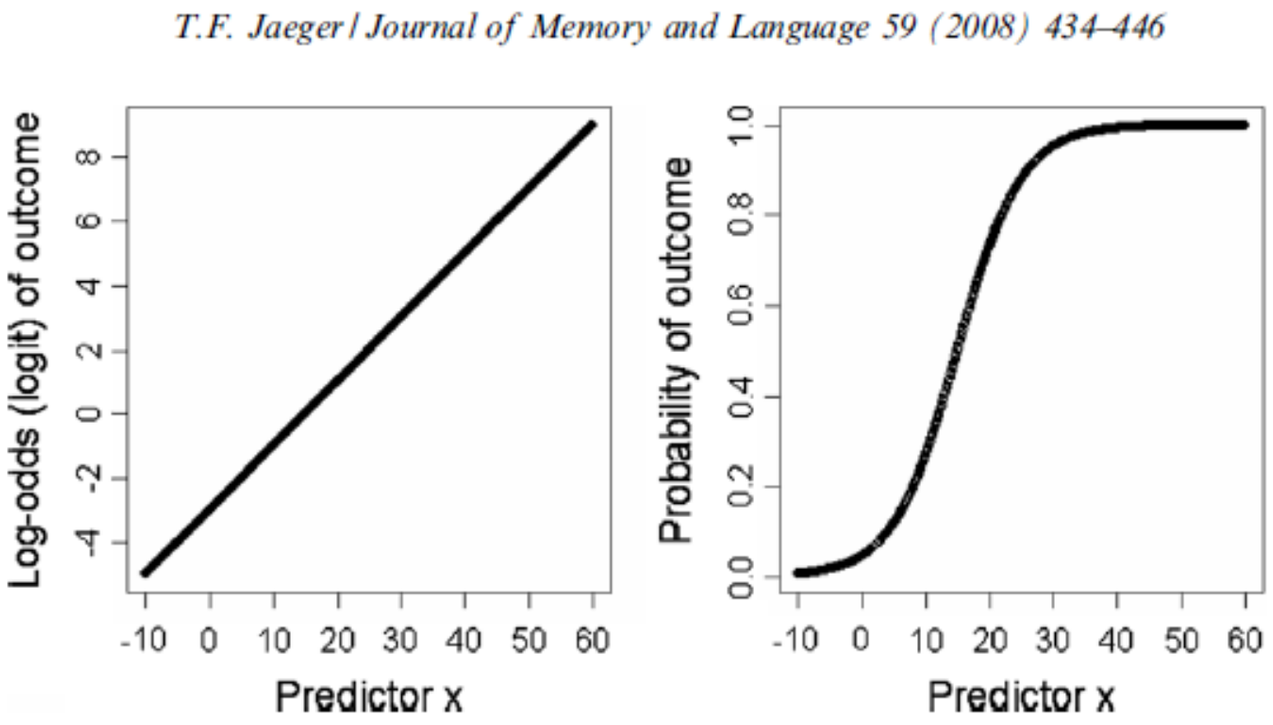
- Inflectional morphology
  - Tense, aspect, evidentiality, negation, plurality, possibility, etc. (28 features from WALS, based on Lupyan & Dale, 2010)
  - E.g. aspect marking in Russian vs. English:
    - "Ya *vy*pil chai" (I PFV+drank tea)
    - "I *finished drinking* the tea." (5 words)

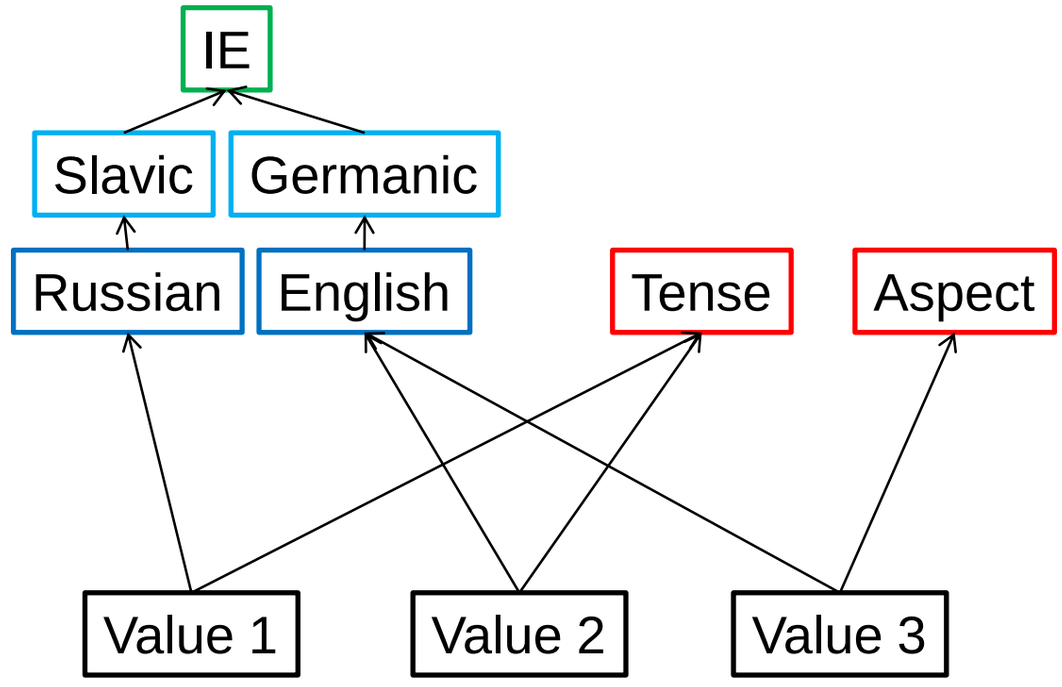
- Cross-language Comparison
  - Different feature value as compared to Dutch (0)
    - Feature value is more complex (26 features)
    - Feature value is less complex (14 features)
    - Feature value is equally complex (9 features)
  - Overlapping feature value (1)

- Missing values
  - Dutch: 9 values
    - 7 values adopted from German, 2 from English (judgments based on WALS chapters)
  - Other languages
    - Impute missing feature values from languages with the most recent common ancestor?

Feature Hierarchy: Method

- Logistic Mixed Effects Regression
  - Of structural differences on learning difficulty
- Data structure
  - Language nested in genus nested in family, crossed with feature





$$\text{logit}(\pi_{ij}) = \log\left(\frac{\pi_{ij}}{1-\pi_{ij}}\right)$$

Feature Hierarchy: Results

Without Imputation

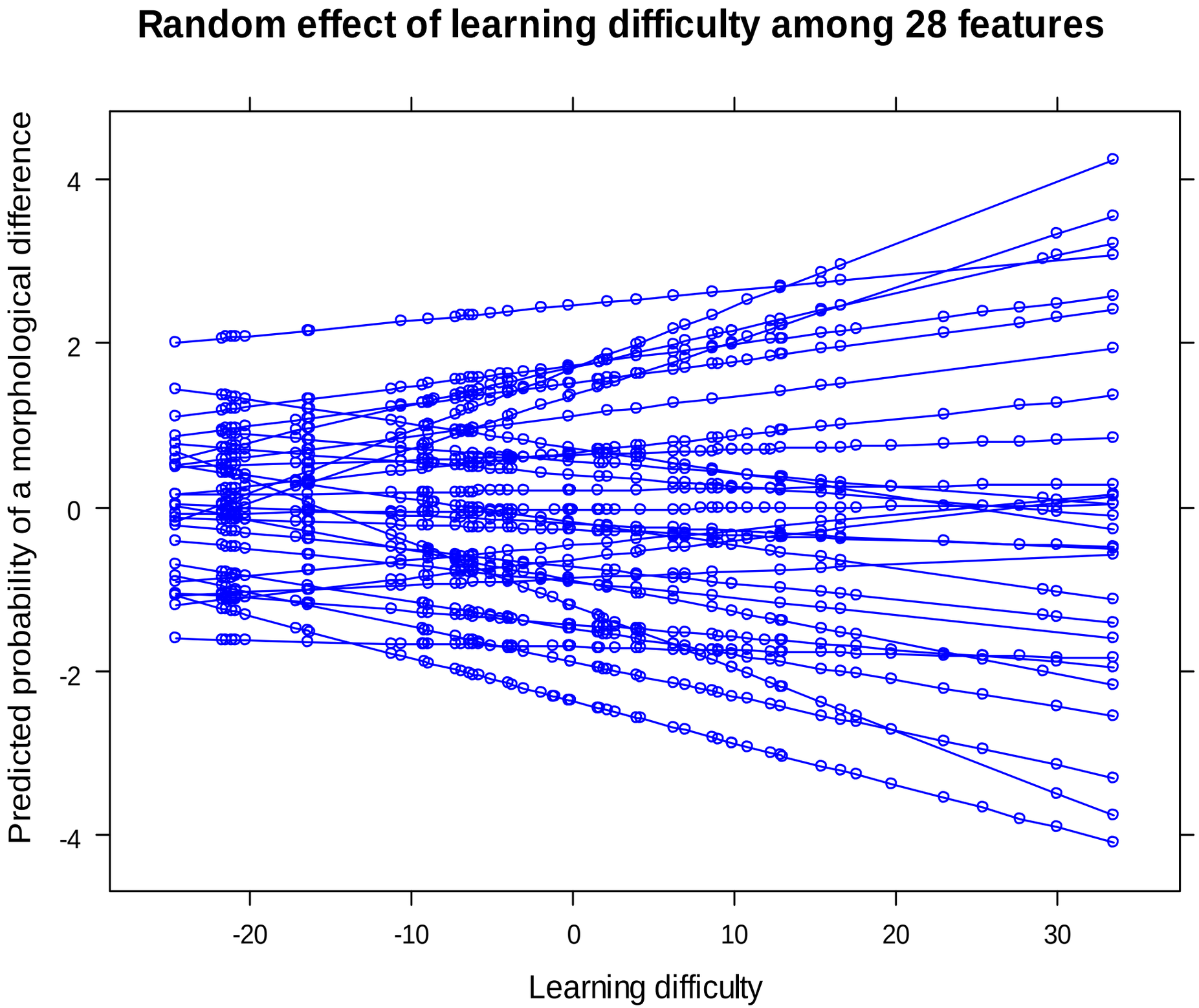
```
Number of obs: 1127, groups: language_name:(genus:family), 65; feature_name, 29;
   genus:family, 29; family, 13
```

Model	Degrees of freedom	Log Likelihood	χ^2	k	Pr(> χ^2)
Null model	5	-646.91			
Random slope	7	-637.04	19.74	2	0.0001

Groups	Std. Dev.	Corr
Feature	1.409087	
Learning Difficulty | Feature	0.049532	0.644
Language : (Genus : Family)	0.000000	
Genus : Family	0.521079	
Family	0.377069	

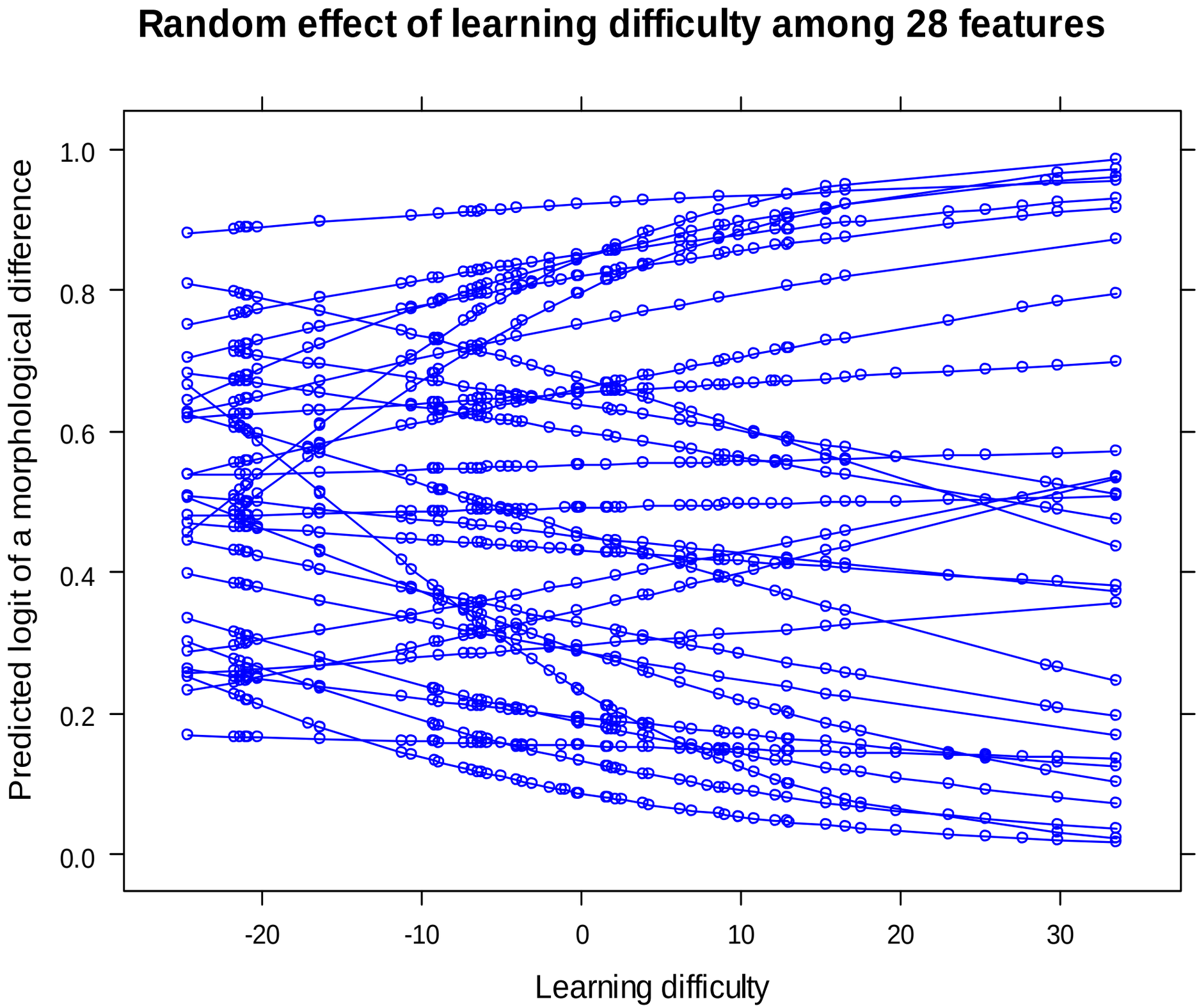
Feature Hierarchy: Results

- Predicted logits
- Map of typological variation to linguistic distance



Feature Hierarchy: Results

- Predicted probabilities
- Map of typological variation to linguistic distance



r	p	feature name
0.79	<0.001	Alignment of Verbal Person Marking
0.74	<0.001	Coding / Occurrence of Plurality
0.59	<0.001	Person Marking on Verbs
0.55	0.003	Case Syncretism
0.51	0.007	Syncretism in Verbal Person / Number Marking
0.46	0.002	Past Tense
0.43	0.002	Epistemic Possibility
0.39	0.064	Fusion of inflectional formatives
0.36	0.007	Coding of Negation
0.36	0.009	Situational Possibility
0.35	0.030	Coding of Possesives
0.32	0.021	Inflectional Morphology
0.28	0.080	Optative
0.25	0.079	Number of Cases
0.14	0.568	Morphological Imperative
0.01	0.991	Possessive Classification
0.00	0.742	Definite / Indefinite Articles
-0.13	0.529	Associative Plural
-0.13	0.365	Perfective / Imperfective
-0.16	0.374	Distance distinctions in demonstratives
-0.18	0.231	Definite Articles
-0.19	0.303	Inflectional Synthesis of the Verb
-0.20	0.247	Future Tense
-0.24	0.134	Coding of Evidentiality
-0.25	0.203	Alignment of Case markings of Full NPs
-0.30	0.016	Polar Question Coding
-0.32	0.028	Overlap b/w Epistemic and Situational Possibility
-0.45	0.001	Expression of Pronomial Subjects

Conclusions

- For most features, learning difficulty increases the probability of typological difference
  - 20 positive correlations (12 significant, 8 not significant)
  - 7 negative correlations (2 significant, 5 not significant)

- Empirical support for the hypothesis that complexity is reduced by L2 learning

- Mixed Effects Regression is useful for modelling variation across features and languages

- Feature hierarchy may be used as a structural measure of linguistic distance