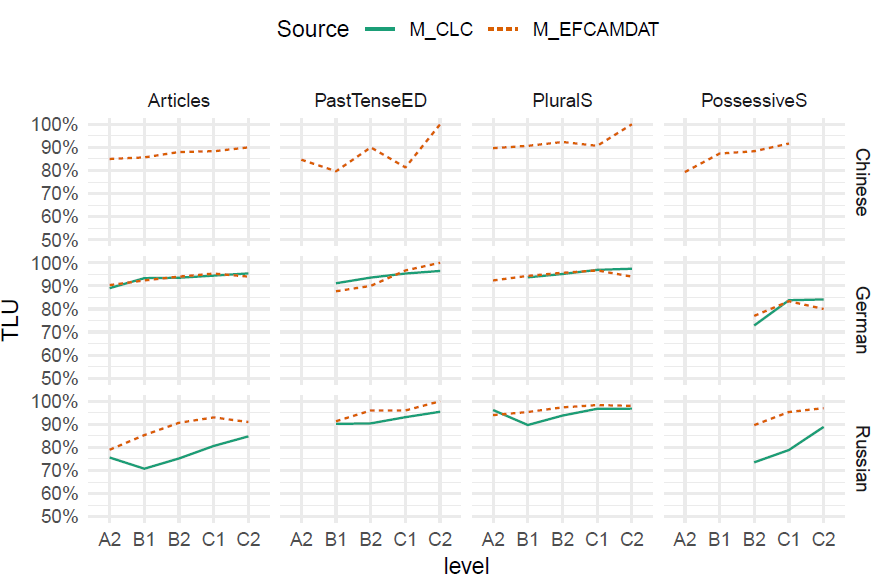
# **Comparison of Morpheme Suppliance Accuracy in EFCAMDAT and Cambridge Learner Corpus (CLC) Across Proficiency Levels**

**Figure 1**

Comparison of Morpheme Suppliance Accuracy in CLC and EFCAMDAT Across Proficiency Levels



*Note.* M\_CLC – data from the Cambridge Learner Corpus as reported in Murakami & Alexopoulou (2016); M\_EFCAMDAT – data from EFCAMDAT (the corpus used in our study) as reported in Murakami (2013)

# **Power Analysis**

To determine the appropriate sample size, we conducted a power analysis in R, for which we simulated a dataset with the following specifications:

* 300 scripts (1 script per learner)
* Two NL-types: [+art] and [-art]
* Three CEFR levels (A2, B1, B2, corresponding to levels 4-6, 7-9, and 10-12, respectively, in EFCAMDAT)

To assess the approximate distribution of the variables we were interested in, we examined 160 randomly selected scripts from the L1-Brazilian and L1-Russian subcorpora (80 scripts each) between EF levels 4-9 (A2-B1 according to CEFR). This enabled us to determine the average number of scorable nominals per script (*M* = 11.5, *SD* = 3) and the average accuracy rate (80%). We also used the average values from the observed data to specify parameter values for the predictor variables in the simulated dataset, which are given in Table 1[[1]](#footnote-1). For example, the average accuracy rate for [+art] learners in the preliminary dataset was 85%, which is 5% above the overall average. Thus, we specified the effect of [+art] L1-type as +0.05 (with the intercept at 0.80).

**Table 1**

Parameter Values for Predictor Variables in Simulated Dataset

| *Predictors/* | **Set accuracy rate**  **(on a scale 0-1)** | |
| --- | --- | --- |
| *[+art]* | *[-art]* |
| Intercept (mean) + L1-type | 0.80 +0.05 | 0.80 -0.05 |
| Level  A2  B1  B2 | -0.06  +0.03  +0.05 | 0  0  +0.5 |
| Definiteness  Definite  Indefinite | +0.02  0 | -0.05  +0.03 |
| Noun type  Singular  Mass  Plural | 0  -0.05  +0.07 | -0.07  +0.05  +0.14 |
| Specificity  Specific  Non-specific | +0.02  -0.02 | -0.02  +0.04 |
| Abstractness  Concrete  Abstract | +0.03  -0.02 | -0.02  +0.03 |
| Modifier  Modifier  No modifier | -0.04  +0.03 | -0.04  +0.03 |
| Syntactic position  Subject  Object  Predicate | 0  +0.01  -0.04 | 0  +0.01  -0.04 |

To introduce random variation for the mixed model, we randomly generated 300 normally distributed numbers (one for each learner), *M* = 0, *SD* = 0.15 log odds, which were added to the means of each respective script ID, which was equivalent to learner ID in this set (as there was one script per learner).

The final score (i.e. the dependent variable value, which could be 0 in case of an incorrect response or 1 in case of a correct response) for each specific data point was determined as follows. First, we summed up the intercept, all the relevant parameter values, and the random variation number for each data point. The resulting number was set as the probability of a correct response (1) for that specific data point. Finally, we used the rbinom function in R, which generates binomially distributed random values, to generate the score of 0 or 1 for each data point based on the predetermined probability. For the example in Table 2, rbinom would generate 1 with a 64% probability.

**Table 2**

Final Score Calculation for an Example Data Point

|  |  |
| --- | --- |
| **Data point characteristics** | **Calculation** |
| [-art]  Level B1  Indefinite  Singular  Specific  Abstract  No modifier  Object  Random variance number  **Probability of 1 (correct response)**  **Final score**[[2]](#footnote-2) | 0.80 (intercept)  -0.05  +0  +0.03  -0.07  -0.02  +0.03  +0.03  +0.01  -0.12  **0.64**  **1** |

We then fitted a generalised linear mixed-effects regression model onto the simulated dataset. The final accuracy score (0/1) was the binary dependent variable. The model included 7 fixed effects:

* NL-type: [+art] or [-art]
* Proficiency level (A2/B1/B2)
* Definiteness (definite or indefinite)
* Specificity (specific or non-specific)
* Noun type, combining countability and number (count singular, count plural, or mass)
* Modifier (present or absent)
* Abstractness (abstract or concrete)

We also included a two-way interaction between the NL-type and all the independent variables, except for modifier presence, resulting in 5 two-way interactions.

The writing (script) ID was included as a random effect to control for individual variation. The syntactic position was also initially included in the model but did not yield a statistically significant effect for the simulated dataset and was thus not included in the final model for power analysis[[3]](#footnote-3). The results of the model are presented in Table 3.

**Table 3**

Simulated Corpus Dataset Model Results

|  | Accuracy Rate | | | |
| --- | --- | --- | --- | --- |
| *Predictors* | *Log-Odds* | *std. Error* | *95% CI* | *p* |
| (Intercept) | 1.88 \*\*\* | 0.20 | 1.49 | 2.27 | <0.001 |
| L1: [-art] | -1.30 \*\*\* | 0.25 | -1.78 | -0.81 | <0.001 |
| level: B1 | 0.95 \*\*\* | 0.20 | 0.55 | 1.34 | <0.001 |
| level: B2 | 1.08 \*\*\* | 0.20 | 0.68 | 1.47 | <0.001 |
| def: indefinite | -0.11 | 0.23 | -0.56 | 0.35 | 0.641 |
| spec: non-specific | -0.66 \*\* | 0.21 | -1.07 | -0.24 | 0.002 |
| Ntype: pl | 0.52 \* | 0.24 | 0.06 | 0.98 | 0.028 |
| Ntype: mass | -0.86 \*\*\* | 0.18 | -1.22 | -0.51 | <0.001 |
| abstr: concrete | 0.53 \*\* | 0.17 | 0.20 | 0.85 | 0.002 |
| mod: mod | -0.30 \*\* | 0.11 | -0.52 | -0.08 | 0.007 |
| L1: [-art] \* level: B1 | -0.80 \*\* | 0.25 | -1.29 | -0.30 | 0.002 |
| L1: [-art] \* level: B2 | -0.43 | 0.26 | -0.94 | 0.08 | 0.095 |
| L1: [-art] \* def: indefinite | 0.65 \* | 0.28 | 0.10 | 1.20 | 0.021 |
| L1: [-art] \* spec: non-specific | 0.89 \*\* | 0.28 | 0.35 | 1.43 | 0.001 |
| L1: [-art] \* Ntype: pl | 1.14 \*\*\* | 0.32 | 0.52 | 1.76 | <0.001 |
| L1: [-art] \* Ntype: mass | 1.58 \*\*\* | 0.24 | 1.11 | 2.05 | <0.001 |
| L1: [-art] \* abstr: concrete | -0.70 \*\*\* | 0.21 | -1.12 | -0.29 | 0.001 |
| Random Effects by Writing ID | | | | |
| SD (Intercept) | 0.06 | | | |
| N lrn\_id | 300 | | | |
| Observations | 3332 | | | |
| Marginal R2 / Conditional R2 | 0.189 / 0.190 | | | |

*Note.* The reference levels of multi-level variables in this model are “A2” for level, “sing” for Ntype.

We chose the effect with the smallest statistically significant *β*-coefficient, which was the estimate for modifier presence (-0.30), as the basis for the power analysis, and reduced it even further to -0.25 to make sure that the sample size is big enough to identify even a smaller effect. We then used the simr package (Green & Macleod, 2016) to determine the optimal sample size for the model to have enough power to detect this effect. The package works in three steps. First, it uses the given model to generate a new dataset with the same parameters and the same effects estimates. Second, it refits the model on the new dataset. Finally, it tests the new model for statistical significance of the effect of interest. This process is repeated many times for each given sample size, e.g. we ran at least 200 such simulations per sample size. The resulting statistical power estimate is equal to the percentage of models which estimate that the effect of interest is unlikely to be equal to zero (i.e. reject the null hypothesis) for a given sample size. For example, if out of 100 simulations for a sample size of 300 scripts, only 50 simulations detected the expected effect, this means that the statistical power for such a sample size is only 50%. A statistical power of 80% is usually regarded as the gold standard in social sciences (Green & Macleod, 2016).

The result of the power analysis showed that a sample of 6664 observations would be needed to have a statistical power of 84.5%, 95% CI [78.73, 89.22]. Given that the average number of scorable nominals per script was estimated at 11.5 (based on preliminary analysis), one would require 579 scripts for the subcorpus. To be on the safe side, we decided to draw a sample of 660 scripts (165 per NL).

# **Types of Items Excluded from the Analysis**

* Proper nouns (e.g. “Bill”, “Hillary”, but “the Clintons”)
* Second/third etc. nouns in sequences of coordinate nouns where the article is not obligatory. For example, in (1) the noun “highways” was not included.

1. The main justification for this car tax is the need for building and maintaining *the roads* *and highways*. (L1-German, B2, ID 966727)

* Nouns derived from verbs ending in “-ing” in examples like “do the shopping” (however, some well-established nouns of this type were included, e.g. “warning”, “understanding”)
* Cases where the noun is omitted (e.g. “I'm a happy”)
* Nominals which appear to be written in telegraphic style, e.g. bullet points, notes (2);

1. TWO different aspects of security • technical-security - offered options; • user-security - private responsibility. (L1-German, B2, ID 576446)

* Incomprehensible instances

Because we decided to focus on the use of articles specifically rather than determiners more generally, we also excluded nominals introduced by:

* demonstratives “this”, “that”, “these”, “those”, possessive pronouns (e.g. “my”, “her” etc.) or nouns (e.g. “John’s”, “teacher’s” etc.);
* other determiners (“some”, “any”, “no”, “many”, “much”, “more”, “less”, “most”, “least”, “such”, “each”, “every”, “both”, “enough”, “several”, “all”, “another”, “other”, “what”, “which”);
* quantifiers “a lot of”, “a little”, “a few”, “a (little) bit of”;
* cardinal numbers.

# **Formulaic sequences**

In our data, we identified formulaic sequences manually on a case-by-case basis. In this process we took the following factors into consideration:

* how frequent the sequence is across learners;
* whether the sequence is a relatively fixed expression in English;
* whether the sequence is typically taught as a set phrase in EFL contexts;
* whether the use (or non-use) of the article in the sequence is largely conventional and independent of context.

Fifteen most frequent formulaic sequences are presented in Table 4.

**Table 4**

*Most Frequent Formulaic Sequences in Learner Data*

|  |  |
| --- | --- |
| Formulaic sequence | No. of occurrences |
| next/last + temporal modifier (e.g. year, month, time) | 70 |
| kind/type/sort of N (e.g. type of film, kind of car) | 34 |
| for example | 28 |
| at/to/after etc. work | 24 |
| at/to/after etc. school | 23 |
| a/an + temporal modifier (e.g. twice a week) | 19 |
| at/to the beach | 17 |
| at/to/after etc. university | 16 |
| at night | 15 |
| in addition | 14 |
| all over/around the world | 12 |
| at/from home | 12 |
| in the morning | 11 |
| one of the + superlative adjective + noun (e.g. one of the biggest issues) | 11 |
| on/down/to the street(s) | 10 |

# **Example of a coded script**

We provide an example of a coded script from an L1-Brazilian learner at B1 level, EF level 8, task 1 “Reviewing a song for a website”, writing ID 1017525. All the nominals are numbered and italicised. The codes for each nominal are given in Table 5. Excluded instances show “n/a” codes, and the reason for exclusion is provided in the “Comment” column.

I just listened (1) *home Improvement*, (2) *the song* by (3) *Josh Woodward*. This is (4) *a good song*, but without (5) *cool resources* like (6) *guitars* *and* *Drums solo*. I belive that (7) *a good music* to hear around (8) *the beach*, with (9) *a something friends* during (10) *a barbecue*, for me (11) *this music* looks like (12) *a reggae* with (13) *mix* (14) *country music*. (15) *The letter* talk about (16) *the age* when (17) *the* *people* lived in (18) *the contryside* working like (19) *a farmer* and how is different (20) *the nowadays life style*. On (21) *short words*, regular but (22) *good music* to listened and reflect about what we will need for us and (23) *our family* on (24) *the future*.

**Table 5**

*Coding for the Example Script*

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| # | Correct / Error type | Noun type | Spec. | Abstr. | Syntactic  position | Mod. | Discourse-pragmatic context | Comment |
| 1 | n/a | n/a | n/a | n/a | n/a | n/a | n/a | proper name |
| 2 | error: “the” instead of “a” | count  sing. | spec | concr | appositive | no | n/a |  |
| 3 | n/a | n/a | n/a | n/a | n/a | n/a | n/a | proper name |
| 4 | correct: “a” | count sing. | non-spec | concr | predicate (property) | yes | n/a |  |
| 5 | correct: Ø | count plural | non-spec | abstr | object | yes | n/a |  |
| 6 | error: omitted “a” | count sing. | non-spec | abstr | object | yes | n/a | assuming learner meant “a guitar or drum solo” |
| 7 | error: overused “a” | mass | non-spec | concr | predicate (property) | yes | n/a |  |
| 8 | correct: “the” | count sing. | non-spec | concr | object | no | idiomatic | formulaic |
| 9 | n/a | n/a | n/a | n/a | n/a | n/a | n/a | possibly meant “some friends” |
| 10 | correct: “a” | count sing. | non-spec | concr | object | no | n/a |  |
| 11 | n/a | n/a | n/a | n/a | n/a | n/a | n/a | demonstr. “this” |
| 12 | error: overused “a” | mass | non-spec | abstr | object | no | n/a |  |
| 13 | error: omitted “a” | count sing. | non-spec | abstr | object | no | n/a | assuming learner meant “with a mix of” |
| 14 | correct: Ø | mass | non-spec | concr | object | yes | n/a |  |
| 15 | correct: “the” | count plural | spec | abstr | subject | no | situational | assuming learner meant “the lyrics” |
| 16 | correct: “the” | count sing. | spec | abstr | object | no | explanatory |  |
| 17 | error: overused “the” | count plural | non-spec | concr | subject | no | n/a |  |
| 18 | correct: “the” | mass | non-spec | concr | object | no | kind |  |
| 19 | correct: “a” | count sing. | non-spec | concr | predicate (property) | no | n/a |  |
| 20 | correct: “the” | count sing. | spec | abstr | subject | yes | situational | assuming learner meant “how the modern lifestyle is different” |
| 21 | correct: Ø | count plural | non-spec | abstr | object | yes | n/a |  |
| 22 | correct: Ø | mass | non-spec | concr | predicate (property) | yes | n/a | assuming learner meant “this is regular but good music” |
| 23 | n/a | n/a | n/a | n/a | n/a | n/a | n/a | possessive “our” |
| 24 | correct: “the” | count sing. | spec | abstr | object | no | situational |  |

*Note.* Spec. – specificity/specific, abstr. – abstractness/abstract, concr – concrete, mod. – modifier presence, sing. – singular

# **Technical Details for Statistical Models in the Study**

For all the categorical variables we used effect coding, a.k.a. sum coding or deviation coding (not treatment- or dummy-coding). In effect/sum/deviation coding the mean of the dependent variable is compared to the grand (unweighted) mean rather than the mean for a baseline level. For example, a 0.06 *β*-coefficient for “def: definite” means that the mean accuracy rate for definite nominals (when averaged across all other variables) is 0.06 log odds above the grand mean[[4]](#footnote-4) across definites and indefinites (averaged across all other variables). Note that one of the levels of each variable is not shown in the results tables. For variables with two levels, the coefficient for the omitted level is the same but with the opposite sign (i.e. indefinites are 0.06 log odds below the grand mean). This means that the difference between the means of the two levels is equal to 2 \* coefficient (i.e. 0.12 log odds between definites and indefinites). For variables with more than two levels, the coefficient of the omitted level is such that the sum of all coefficients for the variable is equal to 0. For example, if for the variable “noun type” singular nouns are 0.26 log odds below the grand mean, mass nouns are 0.03 log odds below the grand mean, and plural nouns are 0.26 + 0.03 = 0.29 log odds above the mean (so all three coefficients, (-0.26) + (-0.03) + 0.29 = 0).

The omitted levels of multi-level variables in our models are “Russian” for NL, “plural” for noun type (Ntype), “object” for syntactic position (synt), “explanatory” for discourse-pragmatic context. The continuous variable Level was centred (i.e. 0 set at the average level).

For binomial regression models, we used the BOBYQA algorithm as suggested by Bolker (2014). To avoid convergence issues, we increased the number of function evaluations from the default 1\*104 to 1\*105 and tightened the final radius of the trust region (which describes the scale of parameter uncertainty on convergence) from the default 2\*10-7 to 2\*10-9.

For multinomial models, we sometimes increased the positive convergence tolerance from the default 1 \* 10-8 up to 1 \* 10-4 to help convergence, always checking that this does not change the estimates significantly. The random effects structures of multinomial models included only random intercepts by writing ID, as including any other components lead to non-convergence. We set the “no error” (correct) outcome as the baseline response. Thus, in model results tables, rows starting with “omit ~” show estimates for the odds of omission errors vs. correct, rows starting with “sub ~” show estimates for substitution errors vs. correct, “over\_a ~” show estimates for overuse of “a” errors vs. correct; “over\_the ~” estimates for overuse of “the” errors vs. correct.

# **Accuracy Model Selection**

To specify the random-effects structure (Table 6), we started with a zero-correlation model and then iteratively removed random effect parameters (Models R1-R3), following Bates et al.’s parsimonious approach (2015). We also decided to drop syntactic position by writing ID (Model R4), even though this worsened model fit, but removing it resolved the singularity issue that persisted in Models R1-R3. To avoid an overly complex random effects structure, we also removed modifier by writing ID (Model R5), the variable with the lowest variance. Removing any further parameters from the random effects structure significantly worsened model fit. Once we arrived at the minimally required random effects structure, we added correlations back in, which improved model fit significantly (Model R6). However, with the addition of interactions between fixed effects, dropping correlation parameters did not significantly decrease the goodness of fit (cf. Model F1 and Model F2 in Table 7). Since removing correlations did not significantly change the estimates of the fixed effects, we returned to a zero-correlation model.

The process of selecting the fixed effects structure is shown in Table 7 and Table 8. The following interactions were expected and tested based on previous research:

1. Definiteness \* noun type

Different combinations of the levels of these predictors require the use of different articles (definite singulars/mass/plurals require “the”, indefinite singulars requires “a”, indefinite mass/plurals require Ø), and we expect different accuracy rates in each of these subgroups (e.g. learners are known to omit “a” and “the” but may be more accurate in target Ø contexts).

This interaction was statistically significant (Model F2).

1. Definiteness \* noun type \* NL

We expect that learners with [-art] NLs will show more omission in target “the” and target “a” contexts, but performance in target Ø contexts should be similar across NLs.

This interaction was statistically significant (Model F3).

1. Definiteness \* noun type \* NL \* modifier

A prenominal modifier may increase article omission in target “the” and target “a” contexts in learners with [-art] NLs, but this may not affect target Ø contexts.

This interaction improved model fit, but this was due to the significance of the 3-way interaction between definiteness, noun type, and modifier (Model F4), while adding the NL variable did not lead to significant improvement (Model F5).

1. Definiteness \* noun type \* NL \* specificity

Learners with [-art] NLs may substitute “a” with “the” in specific indefinite count singular contexts and substitute “the” with “a” in non-specific definite contexts (possibly only definite count singular).

The 4-way interaction led to a convergence warning and unreasonably large standard errors (SEs), but the 3-way interaction without the NL variable was significant (Model F6).

1. Definiteness \* noun type \* NL \* specificity \* syntactic position

The effect of specificity hypothesised in the previous bullet point might be especially strong in subject as opposed to object syntactic position.

Considering the above results, this interaction was first attempted without the NL variable, which still led to convergence issues.

1. Definiteness \* noun type \* NL \* level

Learners with [-art] NLs are expected to have lower accuracy than those with [+art] NLs in target “the” and target “a” contexts (but not in target Ø contexts), but the gap might be closing as their proficiency level increases.

This interaction was significant (Model F7).

1. Definiteness \* noun type \* abstractness (Model F8)

Learners may omit articles more often with abstract nouns, as these may be interpreted as mass indefinites, but this should not affect target Ø contexts. Conversely, they may be more accurate in supplying “a” with abstract count singular nouns if “a” is perceived as an individuating device.

This interaction was not significant.

In addition, we hypothesised that the variables potentially contributing to article omission in target “the” and target “a” contexts (modifier, specificity, abstractness) may interact with each other, e.g. omission may be particularly high in contexts which are modified, non-specific and abstract at the same time. We, thus, further attempted interactions H-K, of which only interaction H improved model fit significantly. However, some SEs in this model were relatively large and produced particularly unreliable estimates for mass and plural definites, probably due to considerably smaller number of instances in each subcategory in these contexts. Thus, we reverted to Model F7 as the best model for this dataset.

1. Definiteness \* noun type \* modifier \* specificity (Model F9)
2. Definiteness \* noun type \* modifier \* abstractness (Model F10)
3. Definiteness \* noun type \* specificity \* abstractness (Model F11)
4. Definiteness \* noun type \* modifier \* specificity \* abstractness (Model F12)

**Table 6**

*Selecting Random Effects Structure for Accuracy Model*

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Model R1 | | Model R2 | | Model R3 | | Model R4 | | Model R5 | | Model R6 | |
|  |  | | Model R1  minus NL, spec, synt by topic | | Model R2  minus random effects by topic | | Model R3  Minus synt by writing ID | | Model R4  minus modif by writing ID | | Model R5  + correlations between random effects parameters | |
| *Predictors* | *Log-Odds* | *SE* | *Log-Odds* | *SE* | *Log-Odds* | *SE* | *Log-Odds* | *SE* | *Log-Odds* | *SE* | *Log-Odds* | *SE* |
| Intercept (grand mean) | 2.66 \*\*\* | 0.16 | 2.67 \*\*\* | 0.16 | 2.67 \*\*\* | 0.16 | 2.62 \*\*\* | 0.16 | 2.58 \*\*\* | 0.15 | 2.63 \*\*\* | 0.16 |
| def: definite | 0.10 | 0.07 | 0.10 | 0.07 | 0.09 | 0.07 | 0.08 | 0.07 | 0.08 | 0.07 | 0.04 | 0.08 |
| Ntype: singular | -0.27 \*\* | 0.09 | -0.27\*\* | 0.09 | -0.26 \*\* | 0.09 | -0.26 \*\* | 0.09 | -0.26 \*\* | 0.09 | -0.28 \*\* | 0.10 |
| Ntype: mass | -0.05 | 0.11 | -0.05 | 0.11 | -0.08 | 0.10 | -0.08 | 0.10 | -0.08 | 0.09 | -0.01 | 0.12 |
| NL: German | 0.80 \*\*\* | 0.11 | 0.81 \*\*\* | 0.11 | 0.82 \*\*\* | 0.11 | 0.78 \*\*\* | 0.11 | 0.77 \*\*\* | 0.11 | 0.75 \*\*\* | 0.11 |
| NL: Brazilian | 0.03 | 0.10 | 0.04 | 0.10 | 0.04 | 0.10 | 0.04 | 0.09 | 0.03 | 0.09 | 0.03 | 0.10 |
| NL: Chinese | -0.08 | 0.11 | -0.10 | 0.10 | -0.10 | 0.10 | -0.11 | 0.10 | -0.10 | 0.10 | -0.10 | 0.10 |
| Level | 0.13 \* | 0.06 | 0.13 \* | 0.06 | 0.12 \* | 0.06 | 0.10 | 0.06 | 0.10 | 0.06 | 0.09 | 0.06 |
| abstr: concrete | -0.11 | 0.06 | -0.11 | 0.06 | -0.10 | 0.06 | -0.11 \* | 0.05 | -0.11 \* | 0.05 | -0.09 | 0.06 |
| spec: specific | 0.03 | 0.07 | 0.03 | 0.07 | 0.03 | 0.06 | 0.03 | 0.06 | 0.03 | 0.06 | 0.08 | 0.08 |
| mod: no modifier | 0.21 \*\*\* | 0.06 | 0.21 \*\*\* | 0.06 | 0.21 \*\*\* | 0.05 | 0.20 \*\*\* | 0.05 | 0.20 \*\*\* | 0.05 | 0.22 \*\*\* | 0.05 |
| synt: existential | 0.66 | 0.35 | 0.65 | 0.36 | 0.65 | 0.36 | 0.66 | 0.35 | 0.65 | 0.34 | 0.63 | 0.36 |
| synt: predicate | -0.08 | 0.17 | -0.08 | 0.17 | -0.09 | 0.17 | -0.04 | 0.17 | -0.03 | 0.16 | 0.04 | 0.17 |
| synt: subject | -0.34 \* | 0.16 | -0.33 \* | 0.16 | -0.33 \* | 0.16 | -0.33 \* | 0.15 | -0.32 \* | 0.15 | -0.34 \* | 0.15 |
| Random Effects |  |  |  |  |  |  |  |  |  |  |  |  |
| *By writing ID* |  |  |  |  |  |  |  |  |  |  |  |  |
| SD (Intercept) | 0.00 |  | 0.23 |  | 0.19 |  | 0.43 |  | 0.45 |  | 0.65 |  |
| SD (def: definite) | 0.66 |  | 0.66 |  | 0.68 |  | 0.68 |  | 0.67 |  | 0.71 |  |
| SD (Ntype: singular) | 0.68 |  | 0.69 |  | 0.73 |  | 0.72 |  | 0.70 |  | 1.01 |  |
| SD (Ntype: mass) | 0.60 |  | 0.61 |  | 0.88 |  | 0.82 |  | 0.81 |  | 0.91 |  |
| SD (abstr: concrete) | 0.40 |  | 0.41 |  | 0.49 |  | 0.47 |  | 0.46 |  | 0.40 |  |
| SD (spec: specific) | 0.53 |  | 0.53 |  | 0.55 |  | 0.51 |  | 0.52 |  | 0.58 |  |
| SD (mod: no modifier) | 0.34 |  | 0.34 |  | 0.38 |  | 0.36 |  |  |  |  |  |
| SD (synt: existential) | 0.33 |  | 0.32 |  | 0.27 |  |  |  |  |  |  |  |
| SD (synt: predicate) | 0.00 |  | 0.00 |  | 0.00 |  |  |  |  |  |  |  |
| SD (synt: subject) | 0.56 |  | 0.60 |  | 0.62 |  |  |  |  |  |  |  |
| *By topic* |  |  |  |  |  |  |  |  |  |  |  |  |
| SD (Intercept) | 0.00 |  | 0.00 |  |  |  |  |  |  |  |  |  |
| SD (NL: German) | 0.08 |  |  |  |  |  |  |  |  |  |  |  |
| SD (NL: Brazilian) | 0.00 |  |  |  |  |  |  |  |  |  |  |  |
| SD (NL: Chinese) | 0.34 |  |  |  |  |  |  |  |  |  |  |  |
| SD (def: definite) | 0.11 |  | 0.06 |  |  |  |  |  |  |  |  |  |
| SD (Ntype: singular) | 0.14 |  | 0.15 |  |  |  |  |  |  |  |  |  |
| SD (Ntype: mass) | 0.59 |  | 0.59 |  |  |  |  |  |  |  |  |  |
| SD (abstr: concrete) | 0.23 |  | 0.22 |  |  |  |  |  |  |  |  |  |
| SD (spec: specific) | 0.00 |  |  |  |  |  |  |  |  |  |  |  |
| SD (mod: no modifier) | 0.17 |  | 0.17 |  |  |  |  |  |  |  |  |  |
| SD (synt: existential) | 0.00 |  |  |  |  |  |  |  |  |  |  |  |
| SD (synt: predicate) | 0.00 |  |  |  |  |  |  |  |  |  |  |  |
| SD (synt: subject) | 0.20 |  |  |  |  |  |  |  |  |  |  |  |
| N | 632 wr\_id  123 topic | | 632 wr\_id  123 topic | | 632 wr\_id | | 632 wr\_id | | 632 wr\_id | | 632 wr\_id | |
| Observations | 5772 | | 5772 | | 5772 | | 5772 | | 5772 | | 5772 | |
| PCA (components explaining 100% variance / total components) | 8/10 wr\_id  8/13 topic | | 9/10 wr\_id  5/6 topic | | 9/10 wr\_id | | 7/7 wr\_id | | 6/6 wr\_id | | 6/6 wr\_id | |
| Marginal R2 / Conditional R2 | 0.120 / NA | | 0.122 / NA | | 0.123 / NA | | 0.109 / 0.155 | | 0.105 / 0.157 | |  | |
| AIC | 4781.6 | | 4769.7 | | 4765.4 | | 4781.7 | | 4783.0 | | 4762.6 | |
| log-Likelihood | -2353.8 | | -2354.8 | | -2358.7 | | -2369.8 | | -2371.5 | | -2346.3 | |
| Test against prior model |  | | *χ*2 (7) = 2.05,  *p* = 0.96 | | *χ*2 (6) = 7.7,  *p* = 0.26 | | *χ*2 (3) = 22.3,  *p* = 0.00006\*\*\* | | *χ*2 (1) = 3.30,  *p* = 0.069 | | *χ*2 (15) = 50.44,  *p* = 0.00001\*\*\* | |
| Fit warnings | Singular fit | | Singular fit | | Singular fit | | No warnings | | No warnings | | No warnings | |

*Note.* \* *p* < 0.05   \*\* *p* < 0.01   \*\*\* *p* < 0.001

**Table 7**

*Selecting Fixed Effects Structure for Accuracy Model (Models F1-F6)*

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Model F1 | | | Model F2 | | Model F3 | | Model F4 | | | Model F5 | | | Model F6 | | |
|  | Model R6 in Table 6 +  def \* Ntype | | | Model F1 minus random effects correlations | | Model F2 +  def \* Ntype \* NL | | Model F3 +  def \* Ntype \* modif | | | Model F4 +  def \* Ntype \* modif \* NL | | | Model F4 +  def \* Ntype \* spec | | |
| *Predictors* | *Log-Odds* | *SE* | *Log-Odds* | | *SE* | *Log-Odds* | *SE* | *Log-Odds* | *SE* | *Log-Odds* | | *SE* | *Log-Odds* | | *SE* |
| Intercept (grand mean) | 2.47\*\*\* | 0.15 | 2.45\*\*\* | | 0.15 | 2.47\*\*\* | 0.15 | 2.50\*\*\* | 0.16 | 2.50\*\*\* | | 0.16 | 2.52\*\*\* | | 0.16 |
| def:definite | -0.19\* | 0.08 | -0.22\*\* | | 0.07 | -0.17\* | 0.07 | -0.12 | 0.08 | -0.12 | | 0.08 | -0.06 | | 0.09 |
| Ntype:singular | -0.08 | 0.10 | -0.07 | | 0.09 | -0.08 | 0.09 | -0.14 | 0.10 | -0.14 | | 0.10 | -0.14 | | 0.10 |
| Ntype:mass | 0.04 | 0.13 | -0.10 | | 0.10 | -0.12 | 0.10 | -0.17 | 0.12 | -0.17 | | 0.12 | -0.31\* | | 0.13 |
| NL:German | 0.75\*\*\* | 0.11 | 0.77\*\*\* | | 0.11 | 0.78\*\*\* | 0.13 | 0.76\*\*\* | 0.13 | 0.85\*\*\* | | 0.15 | 0.77\*\*\* | | 0.13 |
| NL:Brazilian | 0.04 | 0.09 | 0.02 | | 0.09 | 0.07 | 0.11 | 0.09 | 0.11 | 0.03 | | 0.13 | 0.09 | | 0.11 |
| NL:Chinese | -0.09 | 0.10 | -0.09 | | 0.10 | -0.03 | 0.12 | -0.02 | 0.12 | -0.02 | | 0.13 | -0.03 | | 0.12 |
| mod:no modifier | 0.20\*\*\* | 0.05 | 0.19\*\*\* | | 0.05 | 0.19\*\*\* | 0.05 | 0.18\*\* | 0.07 | 0.16\* | | 0.07 | 0.18\*\* | | 0.07 |
| abstr:concrete | -0.11 | 0.06 | -0.12\* | | 0.05 | -0.12\* | 0.05 | -0.12\* | 0.05 | -0.12\* | | 0.05 | -0.12\* | | 0.05 |
| spec:specific | 0.10 | 0.07 | 0.09 | | 0.06 | 0.09 | 0.06 | 0.10 | 0.06 | 0.10 | | 0.06 | 0.02 | | 0.08 |
| synt:existential | 0.64 | 0.35 | 0.67 | | 0.34 | 0.68\* | 0.34 | 0.74\* | 0.35 | 0.71\* | | 0.35 | 0.66 | | 0.35 |
| synt:predicate | 0.11 | 0.17 | 0.09 | | 0.16 | 0.07 | 0.16 | 0.06 | 0.16 | 0.07 | | 0.17 | 0.18 | | 0.17 |
| synt:subject | -0.37\* | 0.15 | -0.37\* | | 0.15 | -0.36\* | 0.15 | -0.39\*\* | 0.15 | -0.39\* | | 0.15 | -0.41\*\* | | 0.15 |
| Level | 0.09 | 0.06 | 0.10 | | 0.05 | 0.10 | 0.05 | 0.10 | 0.06 | 0.10 | | 0.06 | 0.09 | | 0.06 |
| def:definite \* Ntype:singular | 0.58\*\*\* | 0.09 | 0.61\*\*\* | | 0.07 | 0.53\*\*\* | 0.07 | 0.46\*\*\* | 0.08 | 0.47\*\*\* | | 0.08 | 0.38\*\*\* | | 0.09 |
| def:definite \* Ntype:mass | 0.03 | 0.11 | -0.09 | | 0.09 | -0.06 | 0.09 | -0.06 | 0.11 | -0.06 | | 0.11 | -0.07 | | 0.12 |
| def:definite \* NL:German |  |  |  | |  | 0.24 | 0.13 | 0.24 | 0.13 | 0.32\* | | 0.15 | 0.24 | | 0.13 |
| def:definite \* NL:Brazilian |  |  |  | |  | 0.22\* | 0.11 | 0.22\* | 0.11 | 0.17 | | 0.13 | 0.23\* | | 0.11 |
| def:definite \* NL:Chinese |  |  |  | |  | 0.19 | 0.11 | 0.20 | 0.12 | 0.20 | | 0.13 | 0.20 | | 0.12 |
| Ntype:singular \* NL:German |  |  |  | |  | 0.08 | 0.14 | 0.10 | 0.14 | 0.07 | | 0.17 | 0.11 | | 0.15 |
| Ntype:mass \* NL:German |  |  |  | |  | -0.30 | 0.19 | -0.30 | 0.19 | -0.35 | | 0.23 | -0.30 | | 0.19 |
| Ntype:singular \* NL:Brazilian |  |  |  | |  | 0.06 | 0.13 | 0.05 | 0.13 | 0.11 | | 0.14 | 0.05 | | 0.13 |
| Ntype:mass \* NL:Brazilian |  |  |  | |  | 0.27 | 0.17 | 0.26 | 0.17 | 0.24 | | 0.20 | 0.27 | | 0.17 |
| Ntype:singular \* NL:Chinese |  |  |  | |  | -0.11 | 0.13 | -0.12 | 0.13 | -0.13 | | 0.15 | -0.11 | | 0.13 |
| Ntype:mass \* NL:Chinese |  |  |  | |  | -0.02 | 0.17 | -0.02 | 0.17 | 0.10 | | 0.20 | -0.02 | | 0.17 |
| def:definite \* Ntype:singular \* NL:German |  |  |  | |  | -0.46\*\*\* | 0.14 | -0.46\*\*\* | 0.14 | -0.48\*\* | | 0.16 | -0.47\*\*\* | | 0.14 |
| def:definite \* Ntype:mass \* NL:German |  |  |  | |  | 0.30 | 0.18 | 0.32 | 0.18 | 0.27 | | 0.22 | 0.34 | | 0.18 |
| def:definite \* Ntype:singular \* NL:Brazilian |  |  |  | |  | -0.04 | 0.12 | -0.06 | 0.12 | -0.01 | | 0.13 | -0.07 | | 0.12 |
| def:definite \* Ntype:mass \* NL:Brazilian |  |  |  | |  | 0.25 | 0.16 | 0.25 | 0.16 | 0.22 | | 0.19 | 0.26 | | 0.16 |
| def:definite \* Ntype:singular \* NL:Chinese |  |  |  | |  | -0.10 | 0.12 | -0.10 | 0.12 | -0.11 | | 0.14 | -0.09 | | 0.12 |
| def:definite \* Ntype:mass \* NL:Chinese |  |  |  | |  | -0.22 | 0.16 | -0.23 | 0.16 | -0.11 | | 0.19 | -0.21 | | 0.16 |
| def:definite \* mod:no modifier |  |  |  | |  |  |  | -0.08 | 0.06 | -0.08 | | 0.07 | -0.07 | | 0.07 |
| Ntype:singular \* mod:no modifier |  |  |  | |  |  |  | 0.00 | 0.07 | -0.03 | | 0.08 | 0.01 | | 0.07 |
| Ntype:mass \* mod:no modifier |  |  |  | |  |  |  | 0.23\* | 0.10 | 0.24\* | | 0.11 | 0.22\* | | 0.10 |
| def:definite \* Ntype:singular \* mod:no modifier |  |  |  | |  |  |  | 0.33\*\*\* | 0.07 | 0.31\*\*\* | | 0.08 | 0.32\*\*\* | | 0.07 |
| def:definite \* Ntype:mass \* mod:no modifier |  |  |  | |  |  |  | -0.15 | 0.10 | -0.15 | | 0.11 | -0.13 | | 0.10 |
| NL:German \* mod:no modifier |  |  |  | |  |  |  |  |  | -0.23 | | 0.14 |  | |  |
| NL:Brazilian \* mod:no modifier |  |  |  | |  |  |  |  |  | 0.07 | | 0.12 |  | |  |
| NL:Chinese \* mod:no modifier |  |  |  | |  |  |  |  |  | 0.01 | | 0.12 |  | |  |
| def:definite \* NL:German \* mod:no modifier |  |  |  | |  |  |  |  |  | -0.10 | | 0.14 |  | |  |
| def:definite \* NL:Brazilian \* mod:no modifier |  |  |  | |  |  |  |  |  | 0.12 | | 0.12 |  | |  |
| def:definite \* NL:Chinese \* mod:no modifier |  |  |  | |  |  |  |  |  | -0.01 | | 0.12 |  | |  |
| Ntype:singular \* NL:German \* mod:no modifier |  |  |  | |  |  |  |  |  | -0.04 | | 0.16 |  | |  |
| Ntype:mass \* NL:German \* mod:no modifier |  |  |  | |  |  |  |  |  | 0.15 | | 0.22 |  | |  |
| Ntype:singular \* NL:Brazilian \* mod:no modifier |  |  |  | |  |  |  |  |  | -0.12 | | 0.13 |  | |  |
| Ntype:mass \* NL:Brazilian \* mod:no modifier |  |  |  | |  |  |  |  |  | 0.06 | | 0.18 |  | |  |
| Ntype:singular \* NL:Chinese \* mod:no modifier |  |  |  | |  |  |  |  |  | 0.05 | | 0.14 |  | |  |
| Ntype:mass \* NL:Chinese \* mod:no modifier |  |  |  | |  |  |  |  |  | -0.21 | | 0.19 |  | |  |
| def:definite \* Ntype:singular \* NL:German \* mod:no modifier |  |  |  | |  |  |  |  |  | 0.03 | | 0.16 |  | |  |
| def:definite \* Ntype:mass \* NL:German \* mod:no modifier |  |  |  | |  |  |  |  |  | 0.08 | | 0.22 |  | |  |
| def:definite \* Ntype:singular \* NL:Brazilian \* mod:no modifier |  |  |  | |  |  |  |  |  | -0.06 | | 0.13 |  | |  |
| def:definite \* Ntype:mass \* NL:Brazilian \* mod:no modifier |  |  |  | |  |  |  |  |  | 0.02 | | 0.18 |  | |  |
| def:definite \* Ntype:singular \* NL:Chinese \* mod:no modifier |  |  |  | |  |  |  |  |  | -0.02 | | 0.14 |  | |  |
| def:definite \* Ntype:mass \* NL:Chinese \* mod:no modifier |  |  |  | |  |  |  |  |  | -0.19 | | 0.19 |  | |  |
| def:definite \* spec:specific |  |  |  | |  |  |  |  |  |  | |  | 0.00 | | 0.07 |
| Ntype:singular \* spec:specific |  |  |  | |  |  |  |  |  |  | |  | 0.18\* | | 0.08 |
| Ntype:mass \* spec:specific |  |  |  | |  |  |  |  |  |  | |  | -0.04 | | 0.11 |
| def:definite \* Ntype:singular \* spec:specific |  |  |  | |  |  |  |  |  |  | |  | -0.08 | | 0.08 |
| def:definite \* Ntype:mass \* spec:specific |  |  |  | |  |  |  |  |  |  | |  | 0.29\*\* | | 0.10 |
| Random Effects by Writing ID |  | | |  | |  | |  | | |  | | |  | | |
| SD (Intercept) | 0.52 | | | 0.49 | | 0.50 | | 0.51 | | | 0.51 | | | 0.51 | | |
| SD (def:definite) | 0.60 | | | 0.62 | | 0.58 | | 0.58 | | | 0.58 | | | 0.58 | | |
| SD (Ntype:singular) | 0.78 | | | 0.61 | | 0.61 | | 0.58 | | | 0.58 | | | 0.58 | | |
| SD (Ntype:mass) | 0.94 | | | 0.78 | | 0.75 | | 0.79 | | | 0.81 | | | 0.76 | | |
| SD (spec:specific) | 0.47 | | | 0.47 | | 0.46 | | 0.48 | | | 0.49 | | | 0.49 | | |
| SD (abstr:concrete) | 0.38 | | | 0.41 | | 0.40 | | 0.40 | | | 0.40 | | | 0.41 | | |
| N | 632 wr\_id | | | 632 wr\_id | | 632 wr\_id | | 632 wr\_id | | | 632 wr\_id | | | 632 wr\_id | | |
| Observations | 5772 | | | 5772 | | 5772 | | 5772 | | | 5772 | | | 5772 | | |
| Marginal R2 / Conditional R2 | 0.142 / 0.207 | | | 0.147 / 0.205 | | 0.162 / 0.220 | | 0.179 / 0.238 | | | 0.183 / 0.243 | | | 0.185 / 0.246 | | |
| AIC | 4708.482 | | | 4697.316 | | 4660.255 | | 4631.930 | | | 4654.115 | | | 4624.410 | | |
| log-Likelihood | -2317.241 | | | -2326.658 | | -2293.127 | | -2273.965 | | | -2267.058 | | | -2265.205 | | |
| Test against prior model | *χ*2 (2) = 58.1,  *p* = 2.5\*10-13\*\*\* (vs. Model R6) | | | *χ*2 (15) = 18.8,  *p* = 0.221 | | *χ*2 (15) = 67.1,  *p* = 1.5\*10-8\*\*\* | | *χ*2 (5) = 38.3,  *p* = 3.2\*10-7\*\*\* | | | *χ*2 (18) = 13.8,  *p* = 0.741 | | | *χ*2 (5) = 17.5,  *p* = 0.003612\*\* (vs. Model F4) | | |
| Fit warnings | No warnings | | | No warnings | | No warnings | | No warnings | | | No warnings | | | No warnings | | |

*Note.* \* *p* < 0.05   \*\* *p* < 0.01   \*\*\* *p* < 0.001

**Table 8**

*Selecting Fixed Effects Structure for Accuracy Model (Models F7-F12)*

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Model F7 | | Model F8 | | Model F9 | | Model F10 | | Model F11 | | Model F12 | |
|  | Model F6 +  def \* Ntype \* NL \* Level | | Model F7 +  def \* Ntype \* abstr | | Model F7 +  def \* Ntype \* modif \* spec | | Model F7 +  def \* Ntype \* modif \* abstr | | Model F7 +  def \* Ntype \* spec \* abstr | | Model F7 +  def \* Ntype \* modif \* spec \* abstr | |
| *Predictors* | *Log-Odds* | *SE* | *Log-Odds* | *SE* | *Log-Odds* | *SE* | *Log-Odds* | *SE* | *Log-Odds* | *SE* | *Log-Odds* | *SE* |
| Intercept (grand mean) | 2.57\*\*\* | 0.17 | 2.58\*\*\* | 0.17 | 3.16 | 2.47 | 2.59\*\*\* | 0.17 | 2.60\*\*\* | 0.17 | 3.51 | 4.98 |
| def:definite | -0.04 | 0.09 | -0.04 | 0.09 | 0.55 | 2.47 | -0.04 | 0.09 | -0.01 | 0.09 | 0.34 | 4.28 |
| Ntype:singular | -0.18 | 0.11 | -0.19 | 0.11 | -0.76 | 2.47 | -0.20 | 0.11 | -0.22 | 0.11 | -1.11 | 4.98 |
| Ntype:mass | -0.29\* | 0.14 | -0.26 | 0.14 | 0.96 | 4.93 | -0.25 | 0.14 | -0.28\* | 0.14 | 0.80 | 7.25 |
| NL:German | 0.87\*\*\* | 0.15 | 0.87\*\*\* | 0.15 | 0.89\*\*\* | 0.15 | 0.88\*\*\* | 0.15 | 0.88\*\*\* | 0.15 | 0.92\*\*\* | 0.15 |
| NL:Brazilian | 0.04 | 0.12 | 0.03 | 0.12 | 0.03 | 0.12 | 0.03 | 0.12 | 0.03 | 0.12 | 0.03 | 0.12 |
| NL:Chinese | -0.06 | 0.12 | -0.07 | 0.12 | -0.07 | 0.12 | -0.06 | 0.12 | -0.08 | 0.12 | -0.09 | 0.13 |
| Level | 0.12 | 0.07 | 0.12 | 0.07 | 0.13 | 0.07 | 0.12 | 0.07 | 0.12 | 0.07 | 0.14 | 0.08 |
| spec:specific | 0.02 | 0.08 | 0.02 | 0.08 | -0.59 | 2.47 | 0.03 | 0.08 | 0.02 | 0.08 | -0.32 | 4.28 |
| mod:no modifier | 0.18\*\* | 0.07 | 0.19\*\* | 0.07 | -0.41 | 2.46 | 0.19\*\* | 0.07 | 0.16\* | 0.07 | -0.18 | 4.28 |
| abstr:concrete | -0.12\* | 0.05 | -0.09 | 0.07 | -0.12\* | 0.05 | -0.07 | 0.08 | -0.05 | 0.08 | -0.36 | 4.76 |
| synt:existential | 0.72\* | 0.35 | 0.70\* | 0.35 | 0.71\* | 0.35 | 0.70 | 0.36 | 0.70\* | 0.35 | 0.68 | 0.36 |
| synt:predicate | 0.15 | 0.17 | 0.17 | 0.17 | 0.13 | 0.17 | 0.18 | 0.17 | 0.16 | 0.17 | 0.16 | 0.17 |
| synt:subject | -0.43\*\* | 0.15 | -0.42\*\* | 0.15 | -0.41\*\* | 0.16 | -0.43\*\* | 0.16 | -0.42\*\* | 0.15 | -0.41\*\* | 0.16 |
| def:definite \* Ntype:singular | 0.36\*\*\* | 0.09 | 0.36\*\*\* | 0.09 | -0.22 | 2.47 | 0.37\*\*\* | 0.10 | 0.32\*\*\* | 0.10 | -0.01 | 4.28 |
| def:definite \* Ntype:mass | -0.03 | 0.13 | -0.04 | 0.13 | 1.24 | 4.93 | -0.03 | 0.13 | -0.06 | 0.13 | 1.59 | 8.09 |
| NL:German \* Level | 0.10 | 0.15 | 0.11 | 0.15 | 0.10 | 0.15 | 0.11 | 0.15 | 0.11 | 0.15 | 0.10 | 0.15 |
| NL:Brazilian \* Level | -0.15 | 0.11 | -0.14 | 0.11 | -0.16 | 0.11 | -0.14 | 0.11 | -0.15 | 0.12 | -0.14 | 0.12 |
| NL:Chinese \* Level | -0.07 | 0.12 | -0.08 | 0.12 | -0.06 | 0.12 | -0.08 | 0.12 | -0.08 | 0.12 | -0.07 | 0.12 |
| def:definite \* NL:German | 0.30\* | 0.15 | 0.31\* | 0.15 | 0.32\* | 0.15 | 0.31\* | 0.15 | 0.32\* | 0.15 | 0.35\* | 0.15 |
| def:definite \* NL:Brazilian | 0.19 | 0.11 | 0.19 | 0.11 | 0.19 | 0.12 | 0.19 | 0.12 | 0.19 | 0.11 | 0.19 | 0.12 |
| def:definite \* NL:Chinese | 0.21 | 0.12 | 0.20 | 0.12 | 0.20 | 0.12 | 0.19 | 0.12 | 0.19 | 0.12 | 0.17 | 0.12 |
| def:definite \* Level | 0.05 | 0.07 | 0.04 | 0.07 | 0.07 | 0.07 | 0.04 | 0.07 | 0.03 | 0.07 | 0.05 | 0.07 |
| def:definite \* spec:specific | 0.01 | 0.08 | 0.01 | 0.08 | -0.61 | 2.47 | -0.01 | 0.08 | 0.01 | 0.08 | -0.92 | 4.98 |
| def:definite \* mod:no modifier | -0.06 | 0.07 | -0.05 | 0.07 | -0.71 | 2.46 | -0.05 | 0.07 | -0.07 | 0.07 | -1.02 | 4.98 |
| Ntype:singular \* NL:German | 0.01 | 0.16 | 0.00 | 0.16 | -0.01 | 0.16 | 0.00 | 0.16 | -0.01 | 0.16 | -0.03 | 0.17 |
| Ntype:mass \* NL:German | -0.18 | 0.23 | -0.18 | 0.23 | -0.14 | 0.24 | -0.18 | 0.23 | -0.18 | 0.23 | -0.13 | 0.24 |
| Ntype:singular \* NL:Brazilian | 0.10 | 0.13 | 0.11 | 0.13 | 0.11 | 0.13 | 0.11 | 0.13 | 0.11 | 0.13 | 0.11 | 0.13 |
| Ntype:mass \* NL:Brazilian | 0.23 | 0.18 | 0.24 | 0.18 | 0.23 | 0.18 | 0.22 | 0.18 | 0.23 | 0.18 | 0.21 | 0.18 |
| Ntype:singular \* NL:Chinese | -0.12 | 0.14 | -0.12 | 0.14 | -0.12 | 0.14 | -0.12 | 0.14 | -0.11 | 0.14 | -0.10 | 0.14 |
| Ntype:mass \* NL:Chinese | -0.08 | 0.18 | -0.08 | 0.18 | -0.10 | 0.18 | -0.08 | 0.18 | -0.07 | 0.18 | -0.10 | 0.19 |
| Ntype:singular \* Level | -0.05 | 0.08 | -0.06 | 0.08 | -0.06 | 0.08 | -0.06 | 0.08 | -0.05 | 0.08 | -0.07 | 0.08 |
| Ntype:mass \* Level | 0.01 | 0.11 | 0.04 | 0.11 | 0.04 | 0.11 | 0.04 | 0.11 | 0.04 | 0.11 | 0.07 | 0.12 |
| Ntype:singular \* spec:specific | 0.18\* | 0.09 | 0.19\* | 0.09 | 0.76 | 2.47 | 0.17 | 0.09 | 0.18\* | 0.09 | 0.49 | 4.28 |
| Ntype:mass \* spec:specific | -0.03 | 0.11 | -0.04 | 0.11 | -1.35 | 4.93 | -0.04 | 0.11 | -0.03 | 0.11 | -1.73 | 8.09 |
| Ntype:singular \* mod:no modifier | -0.00 | 0.07 | -0.01 | 0.08 | 0.54 | 2.47 | -0.01 | 0.08 | 0.02 | 0.08 | 0.33 | 4.28 |
| Ntype:mass \* mod:no modifier | 0.22\* | 0.11 | 0.20 | 0.11 | -1.07 | 4.93 | 0.21\* | 0.11 | 0.22\* | 0.11 | -1.42 | 8.09 |
| def:definite \* NL:German \* Level | 0.04 | 0.15 | 0.05 | 0.15 | 0.04 | 0.15 | 0.04 | 0.15 | 0.05 | 0.15 | 0.03 | 0.15 |
| def:definite \* NL:Brazilian \* Level | -0.17 | 0.11 | -0.17 | 0.11 | -0.18 | 0.11 | -0.16 | 0.11 | -0.17 | 0.11 | -0.18 | 0.12 |
| def:definite \* NL:Chinese \* Level | 0.14 | 0.12 | 0.14 | 0.12 | 0.16 | 0.12 | 0.14 | 0.12 | 0.14 | 0.12 | 0.15 | 0.12 |
| Ntype:singular \* NL:German \* Level | -0.09 | 0.16 | -0.09 | 0.16 | -0.09 | 0.17 | -0.09 | 0.17 | -0.10 | 0.17 | -0.09 | 0.17 |
| Ntype:mass \* NL:German \* Level | 0.35 | 0.23 | 0.35 | 0.23 | 0.34 | 0.23 | 0.34 | 0.23 | 0.36 | 0.23 | 0.35 | 0.24 |
| Ntype:singular \* NL:Brazilian \* Level | 0.21 | 0.13 | 0.20 | 0.13 | 0.22 | 0.13 | 0.20 | 0.13 | 0.21 | 0.13 | 0.21 | 0.13 |
| Ntype:mass \* NL:Brazilian \* Level | -0.15 | 0.18 | -0.13 | 0.18 | -0.17 | 0.18 | -0.13 | 0.18 | -0.14 | 0.18 | -0.17 | 0.18 |
| Ntype:singular \* NL:Chinese \* Level | -0.18 | 0.13 | -0.18 | 0.13 | -0.19 | 0.13 | -0.18 | 0.13 | -0.18 | 0.13 | -0.18 | 0.14 |
| Ntype:mass \* NL:Chinese \* Level | -0.14 | 0.18 | -0.15 | 0.18 | -0.11 | 0.18 | -0.16 | 0.18 | -0.15 | 0.18 | -0.11 | 0.18 |
| def:definite \* Ntype:singular \* NL:German | -0.54\*\*\* | 0.16 | -0.54\*\*\* | 0.16 | -0.55\*\*\* | 0.16 | -0.55\*\*\* | 0.16 | -0.55\*\*\* | 0.16 | -0.58\*\*\* | 0.16 |
| def:definite \* Ntype:mass \* NL:German | 0.43 | 0.22 | 0.43 | 0.22 | 0.47\* | 0.23 | 0.44 | 0.23 | 0.43 | 0.22 | 0.47\* | 0.23 |
| def:definite \* Ntype:singular \* NL:Brazilian | -0.03 | 0.12 | -0.03 | 0.12 | -0.03 | 0.12 | -0.04 | 0.12 | -0.03 | 0.12 | -0.04 | 0.12 |
| def:definite \* Ntype:mass \* NL:Brazilian | 0.24 | 0.17 | 0.25 | 0.17 | 0.23 | 0.17 | 0.24 | 0.17 | 0.25 | 0.17 | 0.23 | 0.17 |
| def:definite \* Ntype:singular \* NL:Chinese | -0.07 | 0.13 | -0.07 | 0.13 | -0.08 | 0.13 | -0.06 | 0.13 | -0.06 | 0.13 | -0.05 | 0.13 |
| def:definite \* Ntype:mass \* NL:Chinese | -0.25 | 0.17 | -0.26 | 0.17 | -0.28 | 0.17 | -0.27 | 0.17 | -0.25 | 0.17 | -0.28 | 0.17 |
| def:definite \* Ntype:singular \* Level | -0.12 | 0.08 | -0.10 | 0.08 | -0.13 | 0.08 | -0.10 | 0.08 | -0.09 | 0.08 | -0.11 | 0.08 |
| def:definite \* Ntype:mass \* Level | 0.26\* | 0.11 | 0.25\* | 0.11 | 0.28\*\* | 0.11 | 0.24\* | 0.11 | 0.25\* | 0.11 | 0.28\* | 0.11 |
| def:definite \* Ntype:singular \* spec:specific | -0.09 | 0.08 | -0.09 | 0.08 | 0.50 | 2.47 | -0.07 | 0.08 | -0.09 | 0.08 | 0.79 | 4.98 |
| def:definite \* Ntype:mass \* spec:specific | 0.33\*\* | 0.11 | 0.33\*\* | 0.11 | -0.97 | 4.93 | 0.31\*\* | 0.11 | 0.33\*\* | 0.11 | -0.82 | 7.25 |
| def:definite \* Ntype:singular \* mod:no modifier | 0.32\*\*\* | 0.07 | 0.30\*\*\* | 0.08 | 0.88 | 2.47 | 0.30\*\*\* | 0.08 | 0.32\*\*\* | 0.08 | 1.19 | 4.98 |
| def:definite \* Ntype:mass \* mod:no modifier | -0.13 | 0.10 | -0.14 | 0.11 | -1.40 | 4.93 | -0.14 | 0.11 | -0.13 | 0.11 | -1.22 | 7.25 |
| def:definite \* Ntype:singular \* NL:German \* Level | -0.04 | 0.16 | -0.04 | 0.16 | -0.04 | 0.16 | -0.03 | 0.16 | -0.05 | 0.16 | -0.03 | 0.16 |
| def:definite \* Ntype:mass \* NL:German \* Level | 0.41 | 0.22 | 0.41 | 0.22 | 0.40 | 0.22 | 0.39 | 0.22 | 0.42 | 0.22 | 0.40 | 0.23 |
| def:definite \* Ntype:singular \* NL:Brazilian \* Level | 0.15 | 0.12 | 0.15 | 0.12 | 0.16 | 0.12 | 0.15 | 0.12 | 0.16 | 0.12 | 0.16 | 0.12 |
| def:definite \* Ntype:mass \* NL:Brazilian \* Level | -0.19 | 0.17 | -0.18 | 0.17 | -0.21 | 0.17 | -0.19 | 0.17 | -0.19 | 0.17 | -0.22 | 0.17 |
| def:definite \* Ntype:singular \* NL:Chinese \* Level | 0.12 | 0.13 | 0.12 | 0.13 | 0.10 | 0.13 | 0.12 | 0.13 | 0.13 | 0.13 | 0.12 | 0.13 |
| def:definite \* Ntype:mass \* NL:Chinese \* Level | -0.22 | 0.17 | -0.22 | 0.17 | -0.18 | 0.17 | -0.22 | 0.17 | -0.22 | 0.17 | -0.18 | 0.17 |
| def:definite \* abstr:concrete |  |  | -0.02 | 0.06 |  |  | 0.01 | 0.08 | 0.02 | 0.07 | 0.27 | 4.21 |
| Ntype:singular \* abstr:concrete |  |  | -0.06 | 0.07 |  |  | -0.10 | 0.09 | -0.11 | 0.08 | 0.20 | 4.76 |
| Ntype:mass \* abstr:concrete |  |  | 0.18 | 0.10 |  |  | 0.24\* | 0.11 | 0.17 | 0.11 | 0.49 | 6.96 |
| def:definite \* Ntype:singular \* abstr:concrete |  |  | 0.05 | 0.07 |  |  | -0.02 | 0.08 | 0.01 | 0.08 | -0.26 | 4.21 |
| def:definite \* Ntype:mass \* abstr:concrete |  |  | 0.04 | 0.09 |  |  | 0.02 | 0.11 | 0.02 | 0.11 | -0.29 | 7.64 |
| spec:specific \* mod:no modifier |  |  |  |  | 0.74 | 2.46 |  |  |  |  | 1.03 | 4.98 |
| def:definite \* spec:specific \* mod:no modifier |  |  |  |  | 0.61 | 2.46 |  |  |  |  | 0.35 | 4.28 |
| Ntype:singular \* spec:specific \* mod:no modifier |  |  |  |  | -0.56 | 2.47 |  |  |  |  | -0.85 | 4.98 |
| Ntype:mass \* spec:specific \* mod:no modifier |  |  |  |  | 1.37 | 4.93 |  |  |  |  | 1.19 | 7.25 |
| def:definite \* Ntype:singular \* spec:specific \* mod:no modifier |  |  |  |  | -0.57 | 2.47 |  |  |  |  | -0.32 | 4.28 |
| def:definite \* Ntype:mass \* spec:specific \* mod:no modifier |  |  |  |  | 1.40 | 4.93 |  |  |  |  | 1.78 | 8.09 |
| spec:specific \* abstr:concrete |  |  |  |  |  |  | -0.04 | 0.08 |  |  | -0.23 | 4.21 |
| def:definite \* spec:specific \* abstr:concrete |  |  |  |  |  |  | -0.06 | 0.07 |  |  | 0.30 | 4.76 |
| Ntype:singular \* spec:specific \* abstr:concrete |  |  |  |  |  |  | 0.13 | 0.08 |  |  | 0.28 | 4.21 |
| Ntype:mass \* spec:specific \* abstr:concrete |  |  |  |  |  |  | 0.02 | 0.11 |  |  | 0.31 | 7.64 |
| def:definite \* Ntype:singular \* spec:specific \* abstr:concrete |  |  |  |  |  |  | 0.08 | 0.08 |  |  | -0.30 | 4.76 |
| def:definite \* Ntype:mass \* spec:specific \* abstr:concrete |  |  |  |  |  |  | -0.13 | 0.11 |  |  | -0.40 | 6.96 |
| abstr:concrete \* mod:no modifier |  |  |  |  |  |  |  |  | -0.06 | 0.07 |  |  |
| def:definite \* abstr:concrete \* mod:no modifier |  |  |  |  |  |  |  |  | -0.07 | 0.07 |  |  |
| Ntype:singular \* abstr:concrete \* mod:no modifier |  |  |  |  |  |  |  |  | 0.06 | 0.08 |  |  |
| Ntype:mass \* abstr:concrete \* mod:no modifier |  |  |  |  |  |  |  |  | 0.01 | 0.11 |  |  |
| def:definite \* Ntype:singular \* abstr:concrete \* mod:no modifier |  |  |  |  |  |  |  |  | 0.10 | 0.08 |  |  |
| def:definite \* Ntype:mass \* abstr:concrete \* mod:no modifier |  |  |  |  |  |  |  |  | 0.03 | 0.11 |  |  |
| mod:no modifier \* abstr:concrete |  |  |  |  |  |  |  |  |  |  | -0.28 | 4.21 |
| spec:specific \* mod:no modifier \* abstr:concrete |  |  |  |  |  |  |  |  |  |  | -0.45 | 4.76 |
| def:definite \* mod:no modifier \* abstr:concrete |  |  |  |  |  |  |  |  |  |  | 0.30 | 4.76 |
| Ntype:singular \* mod:no modifier \* abstr:concrete |  |  |  |  |  |  |  |  |  |  | 0.25 | 4.21 |
| Ntype:mass \* mod:no modifier \* abstr:concrete |  |  |  |  |  |  |  |  |  |  | 0.29 | 7.64 |
| def:definite \* spec:specific \* mod:no modifier \* abstr:concrete |  |  |  |  |  |  |  |  |  |  | 0.20 | 4.21 |
| Ntype:singular \* spec:specific \* mod:no modifier \* abstr:concrete |  |  |  |  |  |  |  |  |  |  | 0.41 | 4.76 |
| Ntype:mass \* spec:specific \* mod:no modifier \* abstr:concrete |  |  |  |  |  |  |  |  |  |  | 0.29 | 6.96 |
| def:definite \* Ntype:singular \* mod:no modifier \* abstr:concrete |  |  |  |  |  |  |  |  |  |  | -0.26 | 4.76 |
| def:definite \* Ntype:mass \* mod:no modifier \* abstr:concrete |  |  |  |  |  |  |  |  |  |  | -0.27 | 6.96 |
| def:definite \* Ntype:singular \* spec:specific \* mod:no modifier \* abstr:concrete |  |  |  |  |  |  |  |  |  |  | -0.10 | 4.21 |
| def:definite \* Ntype:mass \* spec:specific \* mod:no modifier \* abstr:concrete |  |  |  |  |  |  |  |  |  |  | -0.29 | 7.64 |
| Random Effects by Writing ID |  | |  | |  | |  | |  | |  | |
| SD (Intercept) | 0.49 | | 0.48 | | 0.49 | | 0.49 | | 0.48 | | 0.48 | |
| SD (def:definite) | 0.55 | | 0.55 | | 0.55 | | 0.55 | | 0.55 | | 0.54 | |
| SD (Ntype:singular) | 0.55 | | 0.56 | | 0.55 | | 0.56 | | 0.56 | | 0.57 | |
| SD (Ntype:mass) | 0.78 | | 0.78 | | 0.78 | | 0.79 | | 0.78 | | 0.78 | |
| SD (spec:specific) | 0.50 | | 0.51 | | 0.49 | | 0.51 | | 0.51 | | 0.49 | |
| SD (abstr:concrete) | 0.43 | | 0.42 | | 0.43 | | 0.42 | | 0.43 | | 0.44 | |
| N | 632 wr\_id | | 632 wr\_id | | 632 wr\_id | | 632 wr\_id | | 632 wr\_id | | 632 wr\_id | |
| Observations | 5772 | | 5772 | | 5772 | | 5772 | | 5772 | | 5772 | |
| Marginal R2 / Conditional R2 | 0.202 / 0.256 | | 0.204 / 0.257 | | 0.263 / 0.313 | | 0.207 / 0.260 | | 0.205 / 0.257 | | 0.423 / 0.460 | |
| AIC | 4633.290 | | 4638.209 | | 4627.378 | | 4644.344 | | 4647.575 | | 4651.010 | |
| log-Likelihood | -2246.645 | | -2244.105 | | -2237.689 | | -2241.172 | | -2242.787 | | -2226.505 | |
| Test against prior model | *χ*2 (23) = 37.1,  *p* = 0.032\*  (vs. Model F6) | | *χ*2 (5) = 5.1,  *p* = 0.406 | | *χ*2 (6) = 17.9,  *p* = 0.006\*\*  (vs. Model F7) | | *χ*2 (11) = 10.9,  *p* = 0.448  (vs. Model F7) | | *χ*2 (11) = 7.7,  *p* = 0.739  (vs. Model F7) | | *χ*2 (29) = 40.3,  *p* = 0.079  (vs. Model F7) | |
| Fit warnings | No warnings | | No warnings | | No warnings | | No warnings | | No warnings | | No warnings | |

*Note.* \* *p* < 0.05   \*\* *p* < 0.01   \*\*\* *p* < 0.001

# **Error Type Model for Indefinite Count Singular Nouns: Model Selection**

The process of model selection is shown in Table 9. For the random effects structure, we were only able to include random intercepts by writing ID (Model 1), since the addition of any slopes caused errors. We initially included all the relevant fixed effects and tested the following interactions:

1. NL \* level

This interaction had a significant effect in singular indefinites in the Accuracy Model. Indeed, this improved model fit significantly (Model 2).

1. NL \* modifier

This was tested for the Accuracy Model but not confirmed. In this model, the interaction significantly improved model fit according to the likelihood ratio test (Model 3); however, it also led to a considerable reduction in the pseudo-R2 value (Nagelkerke, 1991) and to an increase in AIC. Thus, we decided to exclude this interaction.

1. NL \* specificity

This was also tested for the Accuracy Model but not confirmed. In this model, however, it had a significant effect and improved model fit (Model 4).

1. Modifier, specificity, abstractness

The interactions between these variables were hypothesised for the Accuracy Model but led to various convergence issues. In this dataset, we found a significant interaction between modifier and specificity (Model 5) and between specificity and abstractness (Model 6). Any attempted 3-way interactions with NL did not converge. A 3-way interaction between modifier, specificity, and abstractness was also tested and even improved model fit (Model 7) but led to an increase in AIC and to a lower pseudo-R2 value. We decided not to include this interaction.

**Table 9**

Error Type Model for Singular Indefinites Selection Process

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Model 1 | | Model 2 | | | Model 3 | | Model 4 | | Model 5 | | Model 6 | | | Model 7 | |
|  |  | | Model 1 +  NL \* level | | | Model 2 +  NL \* modif | | Model 2 +  NL \* spec | | Model 4 +  modif \* spec | | Model 5 +  spec \* abstr | | | Model 6 +  modif \* spec \* abstr | |
| *Predictors* | *Log-Odds* | *SE* | | *Log-Odds* | *SE* | *Log-Odds* | *SE* | *Log-Odds* | *SE* | *Log-Odds* | *SE* | | *Log-Odds* | *SE* | *Log-Odds* | *SE* |
| omit~Intercept (grand mean) | -2.48\*\*\* | 0.24 | | -2.53\*\*\* | 0.24 | -2.55\*\*\* | 0.24 | -2.62\*\*\* | 0.25 | -2.61\*\*\* | 0.25 | | -2.61\*\*\* | 0.25 | -2.62\*\*\* | 0.25 |
| sub~Intercept (grand mean) | -3.43\*\*\* | 0.29 | | -3.62\*\*\* | 0.31 | -3.53\*\*\* | 0.30 | -3.70\*\*\* | 0.32 | -3.77\*\*\* | 0.33 | | -3.81\*\*\* | 0.33 | -3.77\*\*\* | 0.33 |
| omit~NL:German | -1.37\*\*\* | 0.27 | | -1.66\*\*\* | 0.33 | -1.66\*\*\* | 0.34 | -1.86\*\*\* | 0.40 | -1.86\*\*\* | 0.40 | | -1.85\*\*\* | 0.40 | -1.84\*\*\* | 0.40 |
| sub~NL:German | -0.30 | 0.33 | | -0.39 | 0.39 | -0.27 | 0.36 | -0.38 | 0.40 | -0.38 | 0.42 | | -0.38 | 0.43 | -0.38 | 0.42 |
| omit~NL:Brazilian | 0.12 | 0.22 | | 0.20 | 0.23 | 0.21 | 0.23 | 0.20 | 0.25 | 0.20 | 0.25 | | 0.19 | 0.25 | 0.19 | 0.25 |
| sub~NL:Brazilian | -0.25 | 0.34 | | -0.20 | 0.37 | -0.55 | 0.40 | -0.18 | 0.37 | -0.17 | 0.39 | | -0.18 | 0.41 | -0.19 | 0.39 |
| omit~NL:Chinese | 0.33 | 0.22 | | 0.52\* | 0.23 | 0.54\* | 0.23 | 0.58\* | 0.24 | 0.58\* | 0.24 | | 0.57\* | 0.24 | 0.56\* | 0.24 |
| sub~NL:Chinese | -0.06 | 0.34 | | 0.04 | 0.37 | 0.18 | 0.34 | -0.02 | 0.39 | -0.03 | 0.41 | | -0.02 | 0.42 | -0.03 | 0.41 |
| omit~mod:no modifier | -0.09 | 0.09 | | -0.08 | 0.09 | -0.02 | 0.10 | -0.08 | 0.09 | -0.12 | 0.10 | | -0.12 | 0.10 | -0.12 | 0.10 |
| sub~mod:no modifier | 0.31\* | 0.14 | | 0.33\* | 0.14 | 0.39\* | 0.16 | 0.34\* | 0.14 | 0.32\* | 0.15 | | 0.32\* | 0.15 | 0.30\* | 0.15 |
| omit~spec:specific | -0.38\*\*\* | 0.11 | | -0.37\*\*\* | 0.11 | -0.37\*\*\* | 0.11 | -0.49\*\*\* | 0.13 | -0.50\*\*\* | 0.14 | | -0.49\*\*\* | 0.14 | -0.50\*\*\* | 0.14 |
| sub~spec:specific | -0.16 | 0.16 | | -0.14 | 0.17 | -0.14 | 0.16 | -0.17 | 0.17 | -0.17 | 0.18 | | -0.20 | 0.18 | -0.23 | 0.18 |
| omit~abstr:concrete | 0.13 | 0.09 | | 0.13 | 0.09 | 0.13 | 0.09 | 0.13 | 0.09 | 0.12 | 0.09 | | 0.09 | 0.10 | 0.10 | 0.10 |
| sub~abstr:concrete | 0.27 | 0.14 | | 0.29\* | 0.15 | 0.25 | 0.14 | 0.29 | 0.15 | 0.29 | 0.15 | | 0.31\* | 0.16 | 0.32\* | 0.16 |
| omit~synt:existential | -0.98 | 0.55 | | -1.00 | 0.54 | -0.95 | 0.54 | -1.01 | 0.54 | -0.97 | 0.54 | | -0.97 | 0.54 | -0.98 | 0.54 |
| sub~synt:existential | 0.11 | 0.58 | | 0.05 | 0.61 | 0.12 | 0.59 | 0.01 | 0.62 | 0.06 | 0.63 | | 0.07 | 0.64 | 0.05 | 0.63 |
| omit~synt:predicate | -0.09 | 0.26 | | -0.09 | 0.26 | -0.09 | 0.26 | -0.08 | 0.26 | -0.08 | 0.26 | | -0.09 | 0.26 | -0.10 | 0.26 |
| sub~synt:predicate | -1.78\*\*\* | 0.47 | | -1.76\*\*\* | 0.48 | -1.75\*\*\* | 0.47 | -1.73\*\*\* | 0.49 | -1.73\*\*\* | 0.49 | | -1.75\*\*\* | 0.50 | -1.76\*\*\* | 0.49 |
| omit~synt:subject | 0.63 | 0.34 | | 0.65 | 0.33 | 0.62 | 0.34 | 0.64 | 0.33 | 0.61 | 0.33 | | 0.61 | 0.33 | 0.63 | 0.33 |
| sub~synt:subject | 1.23\*\* | 0.39 | | 1.24\*\* | 0.41 | 1.19\*\* | 0.39 | 1.22\*\* | 0.41 | 1.18\*\* | 0.42 | | 1.22\*\* | 0.43 | 1.25\*\* | 0.43 |
| omit~Level | -0.34\*\* | 0.13 | | -0.44\*\* | 0.14 | -0.43\*\* | 0.14 | -0.46\*\* | 0.14 | -0.45\*\*\* | 0.14 | | -0.45\*\* | 0.14 | -0.45\*\*\* | 0.14 |
| sub~Level | 0.20 | 0.19 | | 0.30 | 0.21 | 0.28 | 0.19 | 0.30 | 0.22 | 0.32 | 0.23 | | 0.32 | 0.24 | 0.31 | 0.23 |
| omit~NL:German \* Level |  |  | | -0.51 | 0.29 | -0.50 | 0.30 | -0.56 | 0.30 | -0.56 | 0.30 | | -0.56 | 0.30 | -0.55 | 0.30 |
| sub~NL:German \* Level |  |  | | 0.59 | 0.40 | 0.52 | 0.36 | 0.61 | 0.41 | 0.63 | 0.43 | | 0.68 | 0.44 | 0.65 | 0.43 |
| omit~NL:Brazilian \* Level |  |  | | 0.07 | 0.21 | 0.06 | 0.21 | 0.07 | 0.21 | 0.06 | 0.21 | | 0.06 | 0.21 | 0.06 | 0.21 |
| sub~NL:Brazilian \* Level |  |  | | -0.14 | 0.35 | -0.06 | 0.32 | -0.14 | 0.36 | -0.15 | 0.38 | | -0.15 | 0.39 | -0.14 | 0.38 |
| omit~NL:Chinese \* Level |  |  | | 0.64\*\* | 0.21 | 0.66\*\* | 0.22 | 0.65\*\* | 0.22 | 0.64\*\* | 0.21 | | 0.65\*\* | 0.21 | 0.65\*\* | 0.21 |
| sub~NL:Chinese \* Level |  |  | | 0.36 | 0.38 | 0.32 | 0.35 | 0.33 | 0.39 | 0.33 | 0.41 | | 0.29 | 0.42 | 0.32 | 0.41 |
| omit~NL:German \* mod:no modifier |  |  | |  |  | 0.22 | 0.23 |  |  |  |  | |  |  |  |  |
| sub~NL:German \* mod:no modifier |  |  | |  |  | -0.18 | 0.26 |  |  |  |  | |  |  |  |  |
| omit~NL:Brazilian \* mod:no modifier |  |  | |  |  | -0.03 | 0.15 |  |  |  |  | |  |  |  |  |
| sub~NL:Brazilian \* mod:no modifier |  |  | |  |  | 0.75\* | 0.32 |  |  |  |  | |  |  |  |  |
| omit~NL:Chinese \* mod:no modifier |  |  | |  |  | 0.09 | 0.17 |  |  |  |  | |  |  |  |  |
| sub~NL:Chinese \* mod:no modifier |  |  | |  |  | -0.26 | 0.25 |  |  |  |  | |  |  |  |  |
| omit~NL:German \* spec:specific |  |  | |  |  |  |  | -0.34 | 0.30 | -0.34 | 0.30 | | -0.32 | 0.30 | -0.32 | 0.30 |
| sub~NL:German \* spec:specific |  |  | |  |  |  |  | 0.00 | 0.30 | -0.01 | 0.31 | | 0.00 | 0.31 | 0.02 | 0.31 |
| omit~NL:Brazilian \* spec:specific |  |  | |  |  |  |  | -0.09 | 0.19 | -0.08 | 0.19 | | -0.09 | 0.19 | -0.10 | 0.19 |
| sub~NL:Brazilian \* spec:specific |  |  | |  |  |  |  | -0.02 | 0.30 | -0.00 | 0.31 | | -0.02 | 0.32 | -0.04 | 0.31 |
| omit~NL:Chinese \* spec:specific |  |  | |  |  |  |  | 0.03 | 0.18 | 0.01 | 0.18 | | 0.01 | 0.18 | 0.01 | 0.18 |
| sub~NL:Chinese \* spec:specific |  |  | |  |  |  |  | -0.41 | 0.30 | -0.43 | 0.31 | | -0.43 | 0.32 | -0.43 | 0.31 |
| omit~spec:specific \* mod:no modifier |  |  | |  |  |  |  |  |  | -0.12 | 0.10 | | -0.11 | 0.10 | -0.13 | 0.10 |
| sub~spec:specific \* mod:no modifier |  |  | |  |  |  |  |  |  | -0.14 | 0.15 | | -0.15 | 0.15 | -0.18 | 0.15 |
| omit~spec:specific \* abstr:concrete |  |  | |  |  |  |  |  |  |  |  | | -0.09 | 0.10 | -0.07 | 0.10 |
| sub~spec:specific \* abstr:concrete |  |  | |  |  |  |  |  |  |  |  | | 0.17 | 0.16 | 0.15 | 0.16 |
| omit~mod:no modifier \* abstr:concrete |  |  | |  |  |  |  |  |  |  |  | |  |  | 0.04 | 0.09 |
| sub~mod:no modifier \* abstr:concrete |  |  | |  |  |  |  |  |  |  |  | |  |  | 0.05 | 0.15 |
| omit~spec:specific \* mod:no modifier \* abstr:concrete |  |  | |  |  |  |  |  |  |  |  | |  |  | 0.13 | 0.09 |
| sub~spec:specific \* mod:no modifier \* abstr:concrete |  |  | |  |  |  |  |  |  |  |  | |  |  | 0.21 | 0.15 |
| Random Effects by Writing ID | | | |  | |  | |  | |  | | |  | |  | |
| SD omit~(Intercept) | 0.57 | | | 0.55 | | 0.60 | | 0.54 | | 0.52 | | | 0.51 | | 0.53 | |
| SD sub~(Intercept) | 0.52 | | | 0.56 | | 0.51 | | 0.56 | | 0.59 | | | 0.61 | | 0.59 | |
| N | 541 wr\_id | | | 541 wr\_id | | 541 wr\_id | | 541 wr\_id | | 541 wr\_id | | | 541 wr\_id | | 541 wr\_id | |
| Observations | 1679 | | | 1679 | | 1679 | | 1679 | | 1679 | | | 1679 | | 1679 | |
| Pseudo-R2 (Nagelkerke, 1991) | 0.139 | | | 0.146 | | 0.059 | | 0.149 | | 0.174 | | | 0.193 | | 0.170 | |
| AIC | 14509.916 | | | 14507.923 | | 14682.599 | | 14514.609 | | 14468.555 | | | 14432.349 | | 14487.979 | |
| Test against prior model |  | | | *D* (6) = 50.2,  *p* = 4.3\*10-9\*\*\* | | *D* (6) = 56.5,  *p* = 2.4\*10-10\*\*\* | | *D* (6) = 18.9,  *p* = 0.00436\*\* (vs. Model 2) | | *D* (2) = 32.0,  *p* = 1.1\*10-7\*\*\* | | | *D* (2) = 24.9,  *p* = 3.9\*10-6\*\*\* | | *D* (4) = 21.9,  *p* = 0.00021\*\*\* | |

*Note.* \* *p* < 0.05   \*\* *p* < 0.01   \*\*\* *p* < 0.001

# **Error Type Model for Indefinite Mass Nouns: Model Selection**

The process of model selection is shown in Table 10. For the random effects structure, we were only able to include random intercepts by writing ID (Model 1), since the addition of any slopes caused errors. We initially included all the relevant fixed effects, apart from the syntactic position variable, which caused non-convergence. We then tested the interactions between modifier, specificity, and abstractness (Models 2-4), as these were hypothesised in the Accuracy Model (but led to convergence issues); however, none of the interactions improved the model significantly. Thus, Model 1 was chosen as the best model for this dataset.

**Table 10**

*Error Type Model Selection for Indefinite Mass Nouns*

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Model 1 | | Model 2 | | Model 3 | | Model 4 | |
|  |  | | Model 1 +  modif \* spec | | Model 1 +  spec \* abstr | | Model 1 +  modif \* abstr | |
| *Predictors* | *Log-Odds* | *SE* | *Log-Odds* | *SE* | *Log-Odds* | *SE* | *Log-Odds* | *SE* |
| over\_a~Intercept (grand mean) | -2.57\*\*\* | 0.22 | -2.61\*\*\* | 0.23 | -2.56\*\*\* | 0.22 | -2.57\*\*\* | 0.22 |
| over\_the~Intercept (grand mean) | -2.67\*\*\* | 0.23 | -2.68\*\*\* | 0.24 | -2.70\*\*\* | 0.24 | -2.67\*\*\* | 0.23 |
| over\_a~NL:German | -0.46 | 0.41 | -0.52 | 0.41 | -0.45 | 0.40 | -0.45 | 0.41 |
| over\_the~NL:German | 0.37 | 0.33 | 0.40 | 0.33 | 0.37 | 0.33 | 0.37 | 0.33 |
| over\_a~NL:Brazilian | 0.42 | 0.33 | 0.44 | 0.33 | 0.44 | 0.33 | 0.43 | 0.33 |
| over\_the~NL:Brazilian | -0.06 | 0.34 | -0.08 | 0.34 | -0.04 | 0.34 | -0.06 | 0.34 |
| over\_a~NL:Chinese | 0.15 | 0.36 | 0.18 | 0.36 | 0.12 | 0.36 | 0.15 | 0.36 |
| over\_the~NL:Chinese | 0.08 | 0.35 | 0.07 | 0.35 | 0.06 | 0.35 | 0.08 | 0.35 |
| over\_a~mod:no modifier | -0.77\*\*\* | 0.16 | -0.80\*\*\* | 0.17 | -0.78\*\*\* | 0.16 | -0.75\*\*\* | 0.17 |
| over\_the~mod:no modifier | -0.36\* | 0.17 | -0.24 | 0.20 | -0.37\* | 0.17 | -0.37\* | 0.18 |
| over\_a~spec:specific | 0.52\*\* | 0.18 | 0.49\*\* | 0.19 | 0.47\* | 0.19 | 0.53\*\* | 0.18 |
| over\_the~spec:specific | 0.02 | 0.21 | -0.01 | 0.21 | -0.03 | 0.22 | 0.02 | 0.21 |
| over\_a~abstr:concrete | -0.08 | 0.19 | -0.09 | 0.19 | -0.13 | 0.20 | -0.08 | 0.19 |
| over\_the~abstr:concrete | -0.06 | 0.18 | -0.05 | 0.18 | -0.15 | 0.22 | -0.06 | 0.19 |
| over\_a~level | 0.07 | 0.22 | 0.08 | 0.21 | 0.06 | 0.22 | 0.07 | 0.22 |
| over\_a~level | 0.15 | 0.21 | 0.15 | 0.21 | 0.14 | 0.21 | 0.15 | 0.21 |
| over\_a~mod:no modifier \* spec:specific |  |  | -0.24 | 0.17 |  |  |  |  |
| over\_the~mod:no modifier \* spec:specific |  |  | 0.20 | 0.20 |  |  |  |  |
| over\_a~spec:specific \* abstr:concrete |  |  |  |  | -0.19 | 0.18 |  |  |
| over\_the~spec:specific \* abstr:concrete |  |  |  |  | -0.16 | 0.21 |  |  |
| over\_a~mod:no modifier \* abstr:concrete |  |  |  |  |  |  | 0.09 | 0.18 |
| over\_the~mod:no modifier \* abstr:concrete |  |  |  |  |  |  | 0.00 | 0.18 |
| Random Effects by Writing ID |  |  |  |  |  |  |  |  |
| SD over\_a~(Intercept) | 0.55 |  | 0.51 |  | 0.53 |  | 0.54 |  |
| SD over\_the~(Intercept) | 0.44 |  | 0.41 |  | 0.43 |  | 0.43 |  |
| N | 371 wr\_id | | 371 wr\_id | | 371 wr\_id | | 371 wr\_id | |
| Observations | 878 | | 878 | | 878 | | 878 | |
| Pseudo-R2 (Nagelkerke, 1991) | 0.171 | | 0.198 | | 0.158 | | 0.161 | |
| AIC | 460.678 | | 463.117 | | 467.442 | | 466.479 | |
| Test against prior model |  | | *D* (2) = 1.5612,  *p* = 0.458 | | *D* (2) = 2.764,  *p* = 0.251  (vs. Model 1) | | *D* (2) = 1.8009,  *p* = 0.406  (vs. Model 1) | |

*Note.* \* *p* < 0.05   \*\* *p* < 0.01   \*\*\* *p* < 0.001

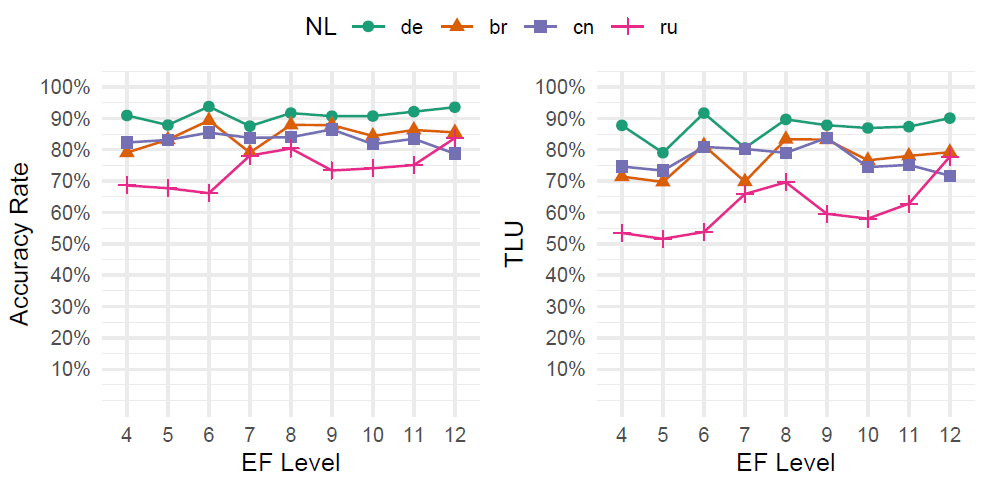
# **TLU Scores**

Figure 2 (right) demonstrates article accuracy development across EF levels as measured by the target-language use (TLU) calculated according to the following formula (Pica, 1983):

Note that TLU excludes correct Ø contexts (e.g. “I bought *milk*”) but includes overuse errors (e.g. “I bought *a milk*”).

**Figure 2**

*Development across EF Levels as Measured by Accuracy Rate (Left) and TLU (Right)*



*Note.* The Accuracy Rate graph from the main text is provided on the left for comparison. The reason that TLU scores are generally lower is because TLU penalises errors in target Ø contexts without rewarding correct Ø.

# **Exploring the Effect of Discourse-Pragmatic Context in Definites**

Due to space limitations and because our findings on the effect of discourse-pragmatic context were inconclusive, we have removed all the sections related to this factor from the main text of the paper and included them below for reference.

## **Discourse-Pragmatic Context: Background**

The definite article is an anaphoric device that can be connected with discourse and contextual antecedents in the following ways (based on Hawkins, 1978):

* Anaphoric: mentioned in the discourse, e.g. “I bought *a book*. *The book* was interesting”.
* Situational: not explicitly mentioned in the discourse but implied by the situation or common knowledge, e.g. “Close *the window*” (immediate situation), “*The President* arrived” (larger situation), “I listened to his new *song*. *The tune* is catchy” (associative anaphoric use in Hawkins).
* Explanatory: unknown but identified by
  + an establishing relative clause, e.g. “Have you read *the book* which Diane recommended?”[[5]](#footnote-5);
  + an associative phrase, e.g. “*the roof* of the house”;
  + a noun-phrase complement, e.g. “I was shocked by *the fact* that they refused”;
  + a nominal modifier, e.g. “*the name* Nelly”.
* Reference to kind (generics), e.g. “*The lion* is a carnivorous animal” (only count singulars).
* Idiomatic: unexplainable/conventional use, e.g. “in *the morning*”.

In summary, the definite article functions to signal referent identifiability, while the indefinite article does not. The indefinite article, on the other hand, introduces referents into the discourse as well as functions to introduce property-denoting predicates. Specificity is not encoded in the English article system, as both definites and indefinites can be specific or non-specific. In indefinite contexts, “a/an” or Ø is used depending on the number and countability of the nominal. The definite article does not depend on these nominal features but performs a range of functions connecting discourse and contextual antecedents.

## **The Role of Discourse: Previous Research**

Highly salient antecedents lead to article omission in subsequent discourse. For example, Robertson (2000) and Trenkic & Pongpairoj (2013) found that article omission in [-art] L1 learners (Chinese and Thai, respectively) was more likely if the antecedent was mentioned in the immediately preceding sentence or visually cued.

Liu & Gleason (2002) found that learners with different L1s were more likely to omit “the” in anaphoric contexts than in other discourse-pragmatic uses of “the” (using Hawkins’s classification, 1978), except for larger situation (cultural) and idiomatic uses, which were the most difficult according to the results of their gap-fill task.

## **Coding Discourse-Pragmatic Contexts**

According to the classification (based on Hawkins) described above, we coded each definite context as anaphoric, situational, explanatory, kind, or idiomatic.

**The Effect of Discourse-Pragmatic Context on Definite Article Accuracy**

To investigate the effect of discourse-pragmatic context on definite article accuracy, we fitted a separate mixed-effects logistic regression model, including only target “the” contexts (*n* = 2039). However, the effect of discourse-pragmatic context was only significant in plural nouns, and the estimates had large confidence intervals, reflecting the low number of instances in mass and plural definite contexts. Other estimates confirmed the results of the Accuracy Model (although the two models are not directly comparable due to being fit on different datasets): NL has the largest main effect, and modifier presence has a small effect on count singulars. We provide more details on the model selection process and results below. Note that we were unable to fit a separate Error Type model on definites, because the model did not converge most probably due to the uneven distribution of errors across Ntypes (only five substitution errors in mass and no substitution errors in plural contexts) and the fact that most errors were made by L1-Russians and L1-Chinese. The model could converge without L1-Germans; however, adding any interactions led to more convergence issues, while the pseudo-R2 for the no-interaction model was only 0.017. Thus, we are not reporting this model here.

### ***Definite Accuracy Model Selection and Results***

This model is fitted on definite contexts only (*n* = 2070). Additionally, we excluded the “kind” discourse-pragmatic context, as instances of this constitute only 1.5% of the data (n = 31). Thus, the following analysis is based on 2039 observations.

Table 13 shows the model selection process. For the random-effects structure, we were only able to include specificity, modifier presence, and syntactic position as random slopes by writing ID (Model 1), since adding any other components caused non-convergence. PCA indicated that all the components were contributing to explaining variance, so there was no need to simplify the structure any further.

The initial model included all the relevant fixed effects. We then used the results of the Accuracy Model to inform the choice of interactions to test:

1. Noun type \* NL

Adding an interaction immediately caused the model to produce inadequate estimates for random effects variance and an overly large intercept (Model 2), which was resolved by removing the syntactic position random slope (Model 3), although this worsened the model fit.

1. Noun type \* modifier

This interaction significantly improved model fit (Model 4). We also attempted a 3-way interaction with NL, but this did not lead to further improvement (Model 5).

1. Noun type \* NL \* level. This interaction was not significant (Model 6).

Since the purpose of this model was to test the effect of discourse-pragmatic context, which did not show a significant effect on its own, we also attempted an interaction between noun type and discourse-pragmatic context to see if singular/mass/plural nouns were differentially affected by discourse-pragmatic context. Indeed, this appeared to be the case (Model 7), and this model was chosen as the best model for this dataset. We further attempted a 3-way interaction with NL, but this model produced inadequate estimates and SEs.

Table 11 shows the final model formula, Table 12 gives the full list of coefficients and model performance metrics.

**Table 11**

*Final Model Formula for Definite Accuracy Model*

|  |  |
| --- | --- |
| Component | Formula |
| Fixed effects  Random effects | Score ~ noun type \* (NL + modifier + discourse-pragmatic context) + level + specificity + abstractness + syntactic position  (modifier + specificity||writing ID) |

The results confirm the Accuracy Model in showing a similar effect of NL in interaction with noun type (Figure 3). The only differences from the Accuracy Model are that (i) the difference between L1-Chinese and L1-Germans in singular definites becomes significant but is still very small, and (ii) the predicted accuracy for L1-Russians is considerably lower for plurals, although this is not surprising given the large confidence interval.

**Figure 3**

Effect of NL across Noun Type

Chart, bar chart, box and whisker chart

Description automatically generated

The interaction between noun type and discourse-pragmatic context (Figure 4, left) is limited to a significant difference (*p* = 0.004) between anaphoric and situational contexts for count plural nouns (examples (3) and (4), respectively).

1. There were a few problems with the house with I signed the contract with the landlord. […] Unfortunately none of *[the]* *problems* has been fixed after I talked to the landlord.

(L1-Chinese, B1, ID 295314)

1. I have always enjoyed having dinner at your restaurant until this time... First, there was an insect in my soup! Second, *[the]* *grilled lamb chops* with fresh vegetables were too salty and spicy.

(L1-Russian, B1, ID 157548)

**Figure 4**

Interaction between Discourse-Pragmatic Context and Noun Type (Left), and Modifier and Noun Type (Right)

Chart, bar chart

Description automatically generated

The effect of modifier presence (Figure 4, right) is also similar to that predicted by the Accuracy Model, albeit slightly smaller.

**Table 12**

*Definite Accuracy Model Results and Performance Metrics*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Accuracy Rate | | | |
| *Predictors* | *Log-Odds* | *std. Error* | *95% CI* | *p* |
| Intercept (grand mean) | 2.41\*\*\* | 0.27 | 1.87 | 2.95 | <0.001 |
| Ntype: singular | 0.66\*\*\* | 0.16 | 0.34 | 0.97 | <0.001 |
| Ntype: mass | -0.35 | 0.22 | -0.78 | 0.08 | 0.115 |
| NL: German | 1.16\*\*\* | 0.25 | 0.68 | 1.64 | <0.001 |
| NL: Brazilian | 0.46\* | 0.22 | 0.03 | 0.88 | 0.035 |
| NL: Chinese | 0.13 | 0.22 | -0.30 | 0.57 | 0.547 |
| mod: no modifier | 0.12 | 0.14 | -0.16 | 0.40 | 0.396 |
| discourse: anaphoric | -0.31 | 0.17 | -0.64 | 0.03 | 0.073 |
| discourse: situational | 0.23 | 0.14 | -0.04 | 0.51 | 0.097 |
| Level | 0.10 | 0.11 | -0.11 | 0.31 | 0.346 |
| abstr: concrete | -0.08 | 0.10 | -0.27 | 0.10 | 0.380 |
| spec: specific | 0.10 | 0.14 | -0.17 | 0.37 | 0.469 |
| synt: existential | 0.42 | 0.34 | -0.25 | 1.10 | 0.221 |
| synt: predicate | -0.01 | 0.21 | -0.41 | 0.39 | 0.968 |
| Ntype: singular \* NL: German | -0.24 | 0.24 | -0.71 | 0.23 | 0.320 |
| Ntype: mass \* NL: German | -0.10 | 0.33 | -0.74 | 0.54 | 0.757 |
| Ntype: singular \* NL: Brazilian | -0.10 | 0.22 | -0.52 | 0.33 | 0.651 |
| Ntype: mass \* NL: Brazilian | 0.68\* | 0.31 | 0.08 | 1.28 | 0.026 |
| Ntype: singular \* NL: Chinese | -0.25 | 0.22 | -0.69 | 0.19 | 0.270 |
| Ntype: mass \* NL: Chinese | -0.31 | 0.29 | -0.89 | 0.26 | 0.287 |
| Ntype: singular \* mod: no modifier | 0.26 | 0.14 | -0.02 | 0.54 | 0.066 |
| Ntype: mass \* mod: no modifier | 0.12 | 0.20 | -0.27 | 0.52 | 0.542 |
| Ntype: singular \* discourse: anaphoric | 0.39\* | 0.20 | 0.00 | 0.78 | 0.049 |
| Ntype: mass \* discourse: anaphoric | 0.17 | 0.28 | -0.38 | 0.71 | 0.547 |
| Ntype: singular \* discourse: situational | -0.49\*\* | 0.16 | -0.81 | -0.17 | 0.003 |
| Ntype: mass \* discourse: situational | 0.15 | 0.22 | -0.28 | 0.58 | 0.507 |
| Random Effects by Writing ID | | | | |
| SD (Intercept) | 0.39 | | | |
| SD (spec: specific) | 1.28 | | | |
| SD (mod: no modifier) | 1.06 | | | |
| N wr\_id | 507 | | | |
| Observations | 2039 | | | |
| Marginal R2 / Conditional R2 | 0.293 / 0.325 | | | |
| Log-likelihood ratio test comparing to the null model (only random effects) | *χ*2 (25) = 172.39, *p* < 1\*10-15 | | | |
| C-statistic | 0.95 (strong predictive power) | | | |
| VIFs | < 2 | | | |
| Overdispersion ratio | 0.476 (*χ*2 = 957.232, *p* = 1) | | | |

*Note.* \* *p* < 0.05   \*\* *p* < 0.01   \*\*\* *p* < 0.001

**Table 13**

*Selecting Random and Fixed Effects Structure for Definite Accuracy Model*

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Model 1 | | Model 2 | | Model 3 | | | Model 4 | | Model 5 | | Model 6 | | | Model 7 | |
|  |  | | Model 1 +  Ntype \* NL | | Model 2 minus synt random slope | | | Model 3 +  Ntype \* modif | | Model 4 +  Ntype \* modif \* NL | | Model 4 +  Ntype \* NL \* level | | | Model 4 +  Ntype \* disourse | |
| *Predictors* | *Log-Odds* | *SE* | *Log-Odds* | *SE* | *Log-Odds* | *SE* | *Log-Odds* | | *SE* | *Log-Odds* | *SE* | | *Log-Odds* | *SE* | *Log-Odds* | *SE* | |
| Intercept (grand mean) | 2.83\*\*\* | 0.63 | 6.19\*\*\* | 0.98 | 2.33\*\*\* | 0.26 | 2.44\*\*\* | | 0.27 | 2.43\*\*\* | 0.28 | | 2.53\*\*\* | 0.29 | 2.41\*\*\* | 0.27 | |
| Ntype:singular | 0.79\*\*\* | 0.16 | 0.85\*\*\* | 0.21 | 0.65\*\*\* | 0.13 | 0.51\*\*\* | | 0.15 | 0.52\*\*\* | 0.15 | | 0.45\*\* | 0.16 | 0.66\*\*\* | 0.16 | |
| Ntype:mass | -0.27 | 0.19 | -0.38 | 0.28 | -0.24 | 0.17 | -0.29 | | 0.21 | -0.28 | 0.22 | | -0.26 | 0.23 | -0.35 | 0.22 | |
| NL:German | 1.32\*\*\* | 0.29 | 1.45\*\* | 0.49 | 1.20\*\*\* | 0.24 | 1.16\*\*\* | | 0.24 | 1.30\*\*\* | 0.30 | | 1.34\*\*\* | 0.29 | 1.16\*\*\* | 0.25 | |
| NL:Brazilian | 0.40 | 0.24 | 0.78 | 0.44 | 0.40 | 0.22 | 0.44\* | | 0.22 | 0.35 | 0.26 | | 0.36 | 0.23 | 0.46\* | 0.22 | |
| NL:Chinese | 0.04 | 0.23 | 0.47 | 0.46 | 0.16 | 0.22 | 0.18 | | 0.22 | 0.17 | 0.26 | | 0.15 | 0.24 | 0.13 | 0.22 | |
| Level | 0.12 | 0.13 | 0.11 | 0.24 | 0.09 | 0.11 | 0.09 | | 0.11 | 0.10 | 0.11 | | 0.15 | 0.14 | 0.10 | 0.11 | |
| abstr:concrete | -0.12 | 0.11 | -0.10 | 0.15 | -0.10 | 0.09 | -0.08 | | 0.09 | -0.07 | 0.09 | | -0.09 | 0.10 | -0.08 | 0.10 | |
| spec:specific | 0.15 | 0.17 | 0.31 | 0.30 | 0.13 | 0.14 | 0.12 | | 0.14 | 0.12 | 0.14 | | 0.13 | 0.14 | 0.10 | 0.14 | |
| mod:no modifier | 0.34\* | 0.14 | 0.45 | 0.25 | 0.30\* | 0.12 | 0.13 | | 0.14 | 0.10 | 0.15 | | 0.14 | 0.15 | 0.12 | 0.14 | |
| synt:predicate | 0.22 | 0.41 | 0.22 | 0.68 | 0.38 | 0.34 | 0.40 | | 0.35 | 0.39 | 0.35 | | 0.40 | 0.35 | 0.42 | 0.34 | |
| synt:subject | 0.12 | 0.30 | 0.13 | 0.47 | 0.02 | 0.20 | -0.01 | | 0.21 | -0.01 | 0.21 | | -0.00 | 0.21 | -0.01 | 0.21 | |
| discourse:anaphoric | -0.14 | 0.16 | -0.13 | 0.22 | -0.13 | 0.14 | -0.17 | | 0.14 | -0.16 | 0.14 | | -0.18 | 0.14 | -0.31 | 0.17 | |
| discourse:situational | 0.02 | 0.14 | -0.08 | 0.20 | 0.02 | 0.12 | 0.03 | | 0.12 | 0.03 | 0.12 | | 0.04 | 0.12 | 0.23 | 0.14 | |
| Ntype:singular \* NL:German |  |  | -0.18 | 0.36 | -0.25 | 0.24 | -0.22 | | 0.24 | -0.31 | 0.29 | | -0.39 | 0.28 | -0.24 | 0.24 | |
| Ntype:mass \* NL:German |  |  | -0.15 | 0.51 | -0.15 | 0.32 | -0.13 | | 0.32 | -0.17 | 0.43 | | 0.05 | 0.40 | -0.10 | 0.33 | |
| Ntype:singular \* NL:Brazilian |  |  | -0.11 | 0.34 | -0.06 | 0.21 | -0.10 | | 0.22 | -0.02 | 0.26 | | -0.02 | 0.22 | -0.10 | 0.22 | |
| Ntype:mass \* NL:Brazilian |  |  | 1.48\*\* | 0.51 | 0.67\* | 0.30 | 0.68\* | | 0.30 | 0.65 | 0.36 | | 0.65\* | 0.32 | 0.68\* | 0.31 | |
| Ntype:singular \* NL:Chinese |  |  | -0.46 | 0.38 | -0.26 | 0.22 | -0.28 | | 0.22 | -0.26 | 0.27 | | -0.26 | 0.23 | -0.25 | 0.22 | |
| Ntype:mass \* NL:Chinese |  |  | -1.05\* | 0.51 | -0.29 | 0.29 | -0.32 | | 0.29 | -0.18 | 0.37 | | -0.44 | 0.31 | -0.31 | 0.29 | |
| Ntype:singular \* mod:no modifier |  |  |  |  |  |  | 0.32\* | | 0.14 | 0.29 | 0.15 | | 0.32\* | 0.15 | 0.26 | 0.14 | |
| Ntype:mass \* mod:no modifier |  |  |  |  |  |  | 0.10 | | 0.20 | 0.11 | 0.21 | | 0.11 | 0.21 | 0.12 | 0.20 | |
| NL:German \* mod:no modifier |  |  |  |  |  |  |  | |  | -0.36 | 0.29 | |  |  |  |  | |
| NL:Brazilian \* mod:no modifier |  |  |  |  |  |  |  | |  | 0.14 | 0.25 | |  |  |  |  | |
| NL:Chinese \* mod:no modifier |  |  |  |  |  |  |  | |  | -0.01 | 0.26 | |  |  |  |  | |
| Ntype:singular \* NL:German \* mod:no modifier |  |  |  |  |  |  |  | |  | 0.10 | 0.29 | |  |  |  |  | |
| Ntype:mass \* NL:German \* mod:no modifier |  |  |  |  |  |  |  | |  | 0.12 | 0.43 | |  |  |  |  | |
| Ntype:singular \* NL:Brazilian \* mod:no modifier |  |  |  |  |  |  |  | |  | -0.15 | 0.25 | |  |  |  |  | |
| Ntype:mass \* NL:Brazilian \* mod:no modifier |  |  |  |  |  |  |  | |  | 0.02 | 0.35 | |  |  |  |  | |
| Ntype:singular \* NL:Chinese \* mod:no modifier |  |  |  |  |  |  |  | |  | -0.07 | 0.26 | |  |  |  |  | |
| Ntype:mass \* NL:Chinese \* mod:no modifier |  |  |  |  |  |  |  | |  | -0.20 | 0.37 | |  |  |  |  | |
| NL:German \* Level |  |  |  |  |  |  |  | |  |  |  | | 0.11 | 0.28 |  |  | |
| NL:Brazilian \* Level |  |  |  |  |  |  |  | |  |  |  | | -0.32 | 0.21 |  |  | |
| NL:Chinese \* Level |  |  |  |  |  |  |  | |  |  |  | | 0.08 | 0.22 |  |  | |
| Ntype:singular \* Level |  |  |  |  |  |  |  | |  |  |  | | -0.10 | 0.13 |  |  | |
| Ntype:mass \* Level |  |  |  |  |  |  |  | |  |  |  | | 0.25 | 0.18 |  |  | |
| Ntype:singular \* NL:German \* Level |  |  |  |  |  |  |  | |  |  |  | | -0.03 | 0.28 |  |  | |
| Ntype:mass \* NL:German \* Level |  |  |  |  |  |  |  | |  |  |  | | 0.73 | 0.40 |  |  | |
| Ntype:singular \* NL:Brazilian \* Level |  |  |  |  |  |  |  | |  |  |  | | 0.24 | 0.21 |  |  | |
| Ntype:mass \* NL:Brazilian \* Level |  |  |  |  |  |  |  | |  |  |  | | -0.38 | 0.30 |  |  | |
| Ntype:singular \* NL:Chinese \* Level |  |  |  |  |  |  |  | |  |  |  | | -0.08 | 0.23 |  |  | |
| Ntype:mass \* NL:Chinese \* Level |  |  |  |  |  |  |  | |  |  |  | | -0.43 | 0.29 |  |  | |
| Ntype:singular \* discourse:anaphoric |  |  |  |  |  |  |  | |  |  |  | |  |  | 0.39\* | 0.20 | |
| Ntype:mass \* discourse:anaphoric |  |  |  |  |  |  |  | |  |  |  | |  |  | 0.17 | 0.28 | |
| Ntype:singular \* discourse:situational |  |  |  |  |  |  |  | |  |  |  | |  |  | -0.49\*\* | 0.16 | |
| Ntype:mass \* discourse:situational |  |  |  |  |  |  |  | |  |  |  | |  |  | 0.15 | 0.22 | |
| Random Effects by Writing ID |  | |  | |  | | |  | |  | |  | | |  | |
| SD (Intercept) | 0.46 | | 2.31 | | 0.34 | | | 0.37 | | 0.37 | | 0.36 | | | 0.39 | |
| SD (spec:specific) | 1.66 | | 4.08 | | 1.33 | | | 1.34 | | 1.33 | | 1.37 | | | 1.28 | |
| SD (mod:no modifier) | 1.35 | | 4.02 | | 1.06 | | | 1.06 | | 1.04 | | 1.09 | | | 1.06 | |
| SD (synt:predicate) | 0.18 | | 1.34 | |  | | |  | |  | |  | | |  | |
| SD (synt:subject) | 1.39 | | 3.91 | |  | | |  | |  | |  | | |  | |
| N | 507 wr\_id | | 507 wr\_id | | 507 wr\_id | | | 507 wr\_id | | 507 wr\_id | | 507 wr\_id | | | 507 wr\_id | |
| Observations | 2039 | | 2039 | | 2039 | | | 2039 | | 2039 | | 2039 | | | 2039 | |
| Marginal R2 / Conditional R2 | 0.327 / 0.368 | | 0.249 / 0.714 | | 0.274 / 0.299 | | | 0.283 / 0.311 | | 0.278 / 0.307 | | 0.305 / 0.331 | | | 0.293 / 0.325 | |
| AIC | 1537.103 | | 1527.165 | | 1555.966 | | | 1551.157 | | 1563.938 | | 1562.887 | | | 1544.820 | |
| log-Likelihood | -749.551 | | -738.582 | | -754.983 | | | -750.579 | | -747.969 | | -745.443 | | | -743.410 | |
| Test against prior model |  | | *χ*2 (6) = 21.9,  *p* = 0.0012\*\* | | *χ*2 (2) = 32.8,  *p* = 7.5\*10-7\*\* | | | *χ*2 (2) = 8.8,  *p* = 0.0122\* | | *χ*2 (9) = 5.2,  *p* = 0.8148 | | *χ*2 (11) = 10.3,  *p* = 0.5062  (vs. Model 4) | | | *χ*2 (4) = 14.3,  *p* = 0.0063\*\*  (vs. Model 4) | |
| Fit warnings | No warnings | | No warnings | | No warnings | | | No warnings | | No warnings | | No warnings | | | No warnings | |

*Note.* \* *p* < 0.05   \*\* *p* < 0.01   \*\*\* *p* < 0.001

## **Discourse-Pragmatic Context: Discussion**

The effect of discourse-pragmatic context on the accuracy of “the” is barely significant. Learners are predicted to be more accurate in situational than in anaphoric contexts but, puzzlingly, in plurals only. Previous research has also found situational contexts to be easier than anaphoric ones (Liu & Gleason, 2002), with higher omission rates in the latter potentially due to perceived redundancy of the article (Robertson, 2000).

One reason we may not have found a reliable effect is that our written production data is monologic and, thus, not as rich in terms of article discourse functions as the dialogues recorded by, for instance, Robertson, whose participants gave oral instructions to each other to draw specific pictures, which elicited numerous instances of anaphoric, situational, and explanatory uses of the definite article.

Additionally, considering the large confidence intervals for the predicted accuracy rate in the anaphoric context and the fact that we were unable to include discourse-pragmatic context as a random effect, this effect might have emerged in plurals because of considerable individual variation. Thus, we cannot reach a definitive conclusion about the effect of discourse-pragmatic context.

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1. Note that the values set for the simulated dataset are in some cases quite different from the estimates obtained in our final data analysis. Nevertheless, what is important is that the magnitude of the effects was similar to what we later found in the actual data. [↑](#footnote-ref-1)
2. Note that the final score will not necessarily be 1 even if the calculated probability is 0.99, but the probability of 1 in this case is much higher than the probability of 0. [↑](#footnote-ref-2)
3. In hindsight, we admit that removing a non-significant variable was probably unjustified. However, it would be of little use to rerun the model used for power simulations after data has already been collected. [↑](#footnote-ref-3)
4. Note that grand mean assigns equal weights to all groups, so it does not take into account the number of observations in each category. For example, if the average accuracy rate is 90% for definites and 94% for indefinites, the grand mean is just 92% regardless of how many instances or definites and indefinites are recorded in the data. [↑](#footnote-ref-4)
5. A relative clause by itself does not make a nominal definite; the uniqueness presupposition still needs to be fulfilled, so there must be only one book recommended. [↑](#footnote-ref-5)