Linguistic and Demographic Factors in an Online Free Translation Task

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Abstract

Humans are remarkably adept at understanding unfamiliar languages, in part by utilizing resources from languages they do know. In this study, we investigated how various linguistic factors (word order, lexical distance) and demographic factors affected the speed and correctness of translations in a multilingual scenario. In a free translation task conducted online, participants read Polish noun phrases and translated them into English text. The noun phrases were varied between noun-adjective and adjective-noun word order, and the number of international words varied among the stimuli. Both the accuracy and total response time were recorded, and additional demographic data was recorded for all participants. Participants were more successful at translating noun phrases composed of two international terms (internationalisms) than those with one or no such words. Additionally, speakers of other Slavic languages were more accurate, despite not knowing Polish, than participants who knew no Slavic languages. Although word order had little or no effect on accuracy for participants overall, speakers of Slavic languages translated the noun-adjective stimuli more accurately overall.

Keywords: Multilingualism, Demographic Factors, Lexical Distance, Polish, Slavic

1. Introduction

As both global integration and mobility within countries increase, more and more people encounter speakers of unknown languages, leading to many interactions without a common language. In this environment, people are forced to rely upon their ability to understand and respond to inputs from other languages, however rudimentarily. This phenomenon, intercomprehension, depends on orthographic, phonetic/phonological, lexical, morphological and syntactic similarities (Möller and Zeevaert, 2015; van Bezooijen and Gooskens, 2005; Gooskens, 2006; Stenger et al., 2019; Stenger and Avgustinova, 2021; Jágrová et al., 2017). In addition, demographic (e.g. age, education, language background) and extra-linguistic (e.g. attitude, exposure) parameters also play an important role (Gooskens and Hilton, 2013).

This study seeks to expand our understanding of how both linguistic and demographic factors determine people's success in both understanding and translating from an unknown language. We investigate two different aspects of cross-linguistic interaction: people's ability to understand another language (receptive multilingualism) and their ability to actively translate from that language (productive multilingualism). Therefore, we conducted an intercomprehension task in which participants read Polish noun phrases and translated them into English. This particular task is valuable as it allows us to not only study how people comprehend an unknown language (receptive multilingualism), but also how they actively translate that language (productive multilingualism).

We investigated specifically how two relevant factors, lexical distance, and word order, affected comprehenders' ability to read Polish and translate it into English. In particular, we focused on lexical distance in terms of the international terminology (internationalisms). Internationalisms are those words present in diverse languages without large differences in meaning, and speakers of those languages can often recognize and understand them in unfamiliar languages (Turska, 2009; Volmert, 1996; Babušytė, 2018). Meanwhile, manipulating word order allows us to observe how a relatively modest but salient grammatical change may affect people's success at intercomprehension. In addition, we also collected a variety of demographic information, including age, gender and language background, to assess what factors may influence people's ability to translate. During the experiment, we recorded both translation accuracy and response time.

2. Related Work

Research on cross-linguistic comprehension has focused on the role of various points of similarity between languages in successful intercomprehension. Unsurprisingly, phonetics plays a key role, especially in discerning cognates (Möller and Zeevaert, 2015; van Bezooijen and Gooskens, 2005; Gooskens, 2006). However, other factors are also important. Firstly, orthographic distance, i.e. the degree of difference in orthography, often opera-

Proceedings of the Fifteenth Language Resources and Evaluation Conference (LREC 2026), pages 8587–8595
11–16 May 2026.

tionalized by Levenshtein distance (Levenshtein, 1965), has been found to strongly predict translation accuracy in text-based intercomprehension tasks (Stenger et al., 2019; Stenger and Avgustinova, 2021). Secondly, lexical distance, i.e. the degree of etymological relatedness or more concretely, the number of cognates, plays a key role (van Bezooijen and Gooskens, 2005; Gooskens, 2006). For example, the amount of international vocabulary shared between the languages facilitates accurate translation. Lexical distance is of particular importance to the previous two factors, as cognates are relevant to utilizing phonetic and orthographic similarity (Möller and Zeevaert, 2015; van Bezooijen and Gooskens, 2005). However, the influence of lexical distance on response time is more complex, with Stenger et al. (2019) finding that orthographic distance effects were not always evident in reaction time measures, possibly due to post-processing effects during typing. Finally, of particular interest to the present study is the finding that German speakers showed slightly higher success rates when translating Polish adjective-noun (AN) phrases (29.68%) compared to noun-adjective phrases (NA) (27.05%) (Jágrová et al., 2017).

Additionally, demographic factors, such as differences in language background, multilingual experience and social background, significantly influence cross-linguistic translation performance. Some authors have found multilingual speakers outperform monolingual speakers in intercomprehension tasks (Jágrová et al., 2017). In particular, people are more successful in comprehending unknown languages if they know another language in the same family (van Bezooijen and Gooskens, 2005; Stenger and Avgustinova, 2021), although the opposite trend was observed in one study in which proficiency in multiple languages from the same family did not necessarily improve translation performance (Berthele, 2011). Even for speakers of the same language, geographic and social factors can also play a role: Gooskens and Hilton (2013) found that southern Norwegians were more successful at understanding Danish than northern Norwegians, even when controlling for subjects' contact with Danish speakers. Lastly, looking at extra-linguistic factors, comprehenders' attitudes towards a language or its speakers seem to have limited impact on intercomprehension (Gooskens, 2024).

3. Methods

The present experiment followed the design of Jágrová (2022); Jágrová (2018) and was conducted online via the MultiLingId Portal (Stenger et al., 2020). Participants were invited to take part in an experiment in which they were asked to translate 39 two-word Polish noun phrases into English in a free translation task. Since they had to both understand written Polish phrases and translate into text, this task incorporates both receptive and productive multilingualism, so that lexical distance varied between 0 and 1, with 0 corresponding to two international words and 1 to no international words. We manipulated lexical distance by differing the number of internationalisms. Word order varied between adjective-noun (AN) and noun-adjective word (NA) order.

After registering, participants divided into two groups. In the first group, participants saw only NPs in the NA order, while in the second group, they saw them only in the AN order. Participants were not informed that the difference between the groups was defined by word order. The experiment was otherwise identical for both groups. They had to translate each stimulus in no more than 20 seconds, with their initial hesitation, typing and final hesitation times being recorded. Within each group, participants were presented with the same 39 NPs, but the order of their presentation was randomized.

When registering for the challenge at the experimental website, participants needed to complete an online background questionnaire in their native language, providing age, gender, level of education, place(s) of upbringing, area of residence, among other information. During the process, it was made explicit that the collected data will be anonymized and used for scientific purposes only, for which the participants needed to give their informed consent. This anonymized background data enabled a multifaceted interpretation of experimental results.

3.1. Materials

The stimuli consisted of 39 noun phrases, made up of a noun and an adjective. We varied the number of internationalisms in the items such that there could be two, one or none in a given stimulus. Stimuli with only one internationalism can be divided into those where the adjective is an internationalism and those where the noun is. Furthermore, we calculated the lexical distance from Polish and English for a given stimulus as the number of internationalisms shared between the Polish stimulus and the English target, normalized to be between 0 and 1. Examples of stimuli with varying lexical distance can be seen in Table 1.

To manipulate word order, we simply reversed the order of these 39 items, resulting in a total of 78 stimuli. No fillers were included. Since any one participant saw only one word order, each translated 39 items in total. The full list of stimuli is provided in Appendix C.

Adj. International	Noun International	Lexical Distance	Example Stimulus	Ex. target	# of Stimuli
1	1	0	polski minister	Polish minister	36
1	0	0.5	polski rząd	Polish government	4
0	1	0.5	nowy projekt	new project	24
0	0	1	nowy dom	new house	14

Table 1: Some stimuli have internationalisms for adjectives, nouns or both. Lexical distance is the normalized number of international terms. All examples are presented in the AN condition.

3.2. Participants

189 individuals participated in the experiment. Of those, 113 chose the first group (NA condition) and 68 the second group (AN condition). Additionally, 8 opted to participate twice and therefore participated in both groups, thus seeing both conditions. There were 44 native speakers of Polish who spoke no other Slavic language, and there were 20 native speakers of at least one other Slavic language (14 Czech only, 2 Bulgarian only, 2 Serbian, 1 Czech and Croatian, 1 Czech and Bulgarian). 77 were native speakers of English. 112 were non-native speakers of English, of whom 77 had 60 or greater of 100 in English writing proficiency. Among non-native speakers, the average English writing score was 69.2 (SD 31.0). The mean age was 30.3 (SD 11.12). 96 were male and 93 were female.

4. Results

4.1. Accuracy

Accuracy was defined based on whether participants' responses perfectly matched the target translation. Correct and incorrect answers were identified automatically. Mean accuracy across conditions was 0.377 (SD 0.485). For the NA stimuli, mean accuracy was 0.362 (SD 0.481), while for the AN stimuli, mean accuracy was 0.400 (SD 0.490). The stimulus with the highest mean accuracy was *minister polski* "Polish minister" with a mean accuracy of 0.698 (sd 0.462), while the stimulus with the lowest mean accuracy was *gmina francuska* "French community" with a mean accuracy of 0.033 (SD 0.180).

4.1.1. Lexical Distance and Word Order

As we hypothesized, increasing lexical distance does affect participants' translation accuracy. At a lexical distance of 0, i.e. when the Polish stimulus and the English target translation share two international terms, 44.5% of the answers submitted by participants were correct. When the lexical distance is increased to 0.5, i.e. when they share only one international term, this percentage drops to 29.6%. Interestingly, however, we do not observe a monotonic decrease in accuracy with increasing lexical distance: at a lexical distance of 1, 32.3% of the answers are correct. As seen in Figure 1, this means we observe a decrease in accuracy between a lexical distance of 0 and 0.5, but not between 0.5 and 1. Note that the slight increase in accuracy from 0.5 to 1 may be due to sample size.

Furthermore, we investigated whether this trend holds for both word order configurations. As seen in Figure 2, for both word orders, we fail to find a significant effect of increasing the lexical distance from 0.5 to 1, but we do observe a sharp decrease between 0 and 0.5 for both groups. In other words, the non-monotonic trend seen in 1 remains approximately the same for both word order configurations. In Section 5, we consider the possible implications of this pattern.

We conducted a Bayesian logistic regression using the brms package (Bürkner, 2017, 2018, 2021) in R (R Core Team, 2021). All binary factors were sum-coded for this model as well as for all following models, with TRUE and FALSE being set to 1 and -1, respectively. The priors for lexical distance and word order were $\mathcal{N}(-1.1, 0.5)$ and $\mathcal{N}(-0.05, 0.5)$, respectively, based on previous research which found a very large negative effect of lexical distance and a small positive effect of AN over NA word order (Jágrová et al., 2017; Stenger and Avgustinova, 2023). A sensitivity analysis with uniform priors can be found in Appendix A. We found a large negative effect of lexical distance of -1.20 (95% CI -1.86 -0.53), corresponding to an odds ratio of 0.30, but a small negative or zero effect of word order of -0.39 (95% CI -0.78 0.00), corresponding to an odds ratio of 0.68.

4.1.2. Demographic Information

We additionally assessed whether knowing Polish and/or another Slavic language correlated with improved accuracy. It is important to note that we only considered whether participants were native speakers or not. Unsurprisingly, Polish speakers were more successful at translating Polish. More interestingly, however, among those participants who did not know Polish, accuracy was far greater among participants knew another Slavic language (48.6%) than those who did not (24.2%), as demonstrated in Figure 3. This trend holds true irrespective of word order (see Figure 4). For example, Czech speakers answered correctly 48.0% of the

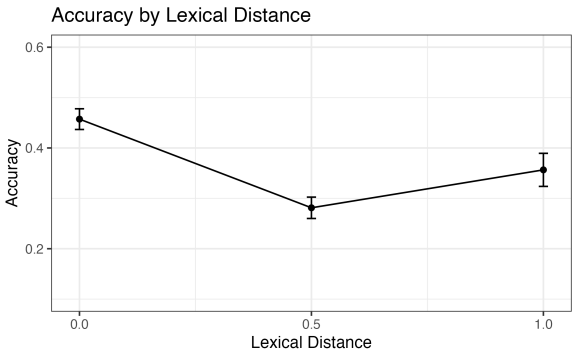

Figure 1: Accuracy by lexical distance between Polish noun phrases and English target translations.

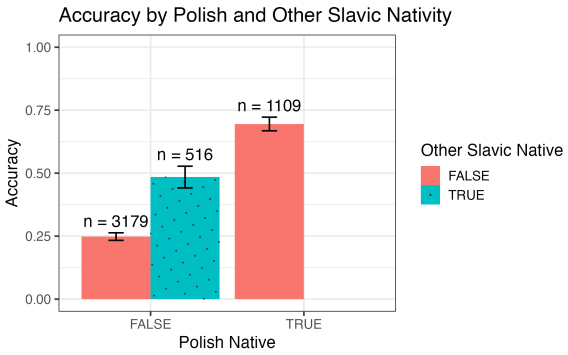

Figure 3: Accuracy grouped by native knowledge of Polish and native knowledge of another Slavic language.

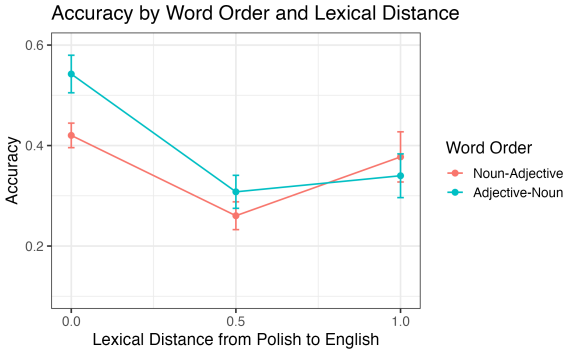

Figure 2: Accuracy by lexical distance between Polish noun phrases and English target translations. grouped by word order.

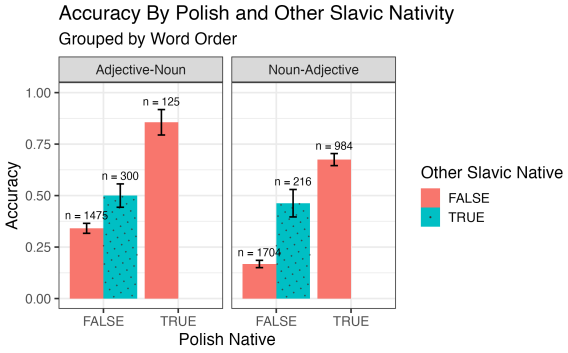

Figure 4: Accuracy, grouped by native knowledge of Polish and native knowledge of another Slavic language, grouped by word-order. For adjective-noun word order, there were no responses by any participant who knew both Polish and another Slavic language.

time overall, whereas the accuracy of those who knew neither Czech nor Polish was only 25.5%. As noted in Section 3.2, most participants who spoke a Slavic language besides Polish spoke Czech.

We again modeled this trend using a Bayesian mixed logistic regression with native knowledge of Polish or another Slavic language as predictors. The respective priors were $\mathcal{N}(0.1, 0.5)$ and $\mathcal{N}(0.05, 0.5)$. We found a large positive effect of Polish knowledge of 1.56 (95% CI 1.24, 1.88) as well as a more modest effect of Slavic knowledge of 0.72 (95% CI 0.33, 1.12). These coefficients respectively equal an odds ratio of 4.76 and 2.51. This model is therefore consistent with the observations indicated by Figure 3. Appendix B contains a sensitivity analysis comparing this model to one with uniform priors.

Additionally, it is important to note that as indicated by Figure 4, for non-Polish speakers, knowledge of another Slavic language was of particular importance when translating the NA stimuli.

4.2. Response Time

Mean response time was 9784 ms (SD 5744). For the NA stimuli, the mean was 9750 ms (SD 5476), while for the AN, the mean was 9834 ms (SD 6132).

Looking at response time overall, one observes a stark contrast between both the mean and the distribution of the response times depending on whether participants answered correctly, which is illustrated by Figure 5. Not only do we see a higher mean response time for incorrect answers, but also a bimodal distribution, seen in the two distinct peaks in the density plot. By contrast, the response time for correct answers are unimodally distributed, i.e. there is a single peak.

4.2.1. Effect of Language Background

The correlation between demographic factors and response time was also a point of interest. In particular, a relevant question was whether knowledge

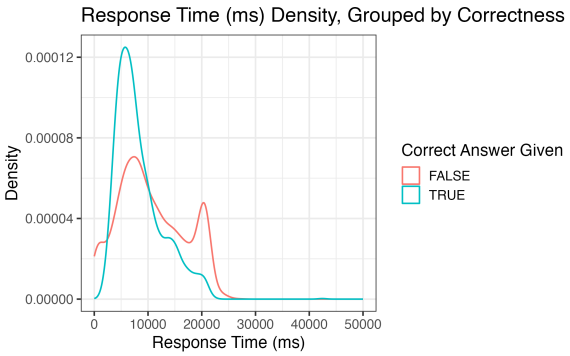

Figure 5: Response time (ms) density, grouped by correctness. Response time is unimodally distributed for correct answers, but bimodally distributed for incorrect ones. Mean response time is lower for correct answers.

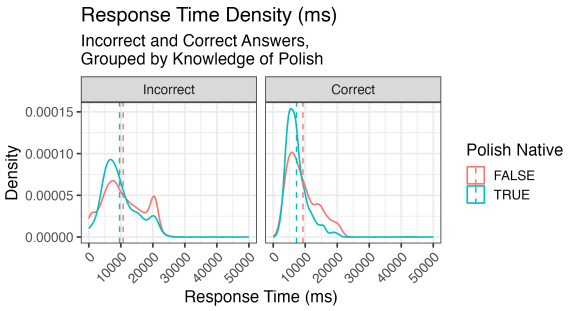

Figure 6: Response time (ms) density for incorrect and correct answers, grouped by knowledge of Polish. Vertical, dashed lines indicate corresponding group means.

of Polish or another Slavic language had any effect on response time to accompany their effect on correctness discussed above. Given the strong differences based on correctness, we divided our observations into those with correct answers and those with incorrect answers. Then, for each of those two divisions, we analyzed the effect of Polish and other Slavic knowledge on response time. The effect of Polish knowledge can be seen in Figure 6, while that of Slavic knowledge is illustrated by Figure 7.

Seeing as Figure 6 indicates a different mean RT depending on whether the participants knew Polish, we created a model with both Polish knowledge and other Slavic language knowledge as factors. For these models of response time, we selected shifted log-normal as the model family and used uniform priors. Among the correct answers, we found a small effect of Polish knowledge (0.14, 95% CI 0.07, 0.21) but a very small effect of another

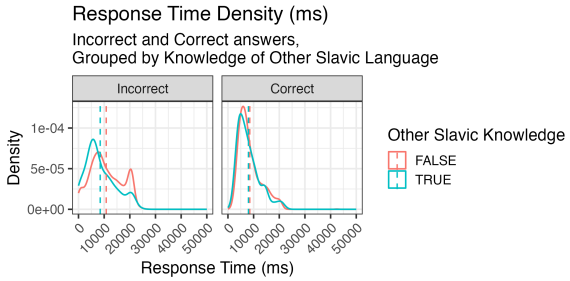

Figure 7: Response time (ms) density for incorrect and correct answers, grouped by knowledge of another Slavic language. Vertical, dashed lines indicate corresponding group means.

English Writing	Polish Native	Accuracy	Participants
< 60	FALSE	0.283	15
< 60	TRUE	0.403	6
≥ 60	FALSE	0.281	130
≥ 60	TRUE	0.739	38

Table 2: Accuracy grouped by English writing proficiency out of 100 and Polish nativity. Number of participants provided for each group.

Slavic language knowledge (0.11, 95% CI 0.01, 0.21). This indicates that while Polish participants answered more quickly, knowing another Slavic language might be much less helpful in respect to speed than to accuracy.

5. Discussion

As we hypothesized, we observed that lexical distance negatively correlates with accuracy, i.e. participants are more successful in intercomprehension when they encounter internationalisms, consistent with van Bezooijen and Gooskens (2005); Gooskens (2006). Interestingly, as revealed in Figure 2, we observed no significant difference between a lexical distance of 0.5 and 1. It is entirely possible that this is purely due to sampling. Had we collected more data from a more diverse group of participants, we may have observed a monotonic decrease from 0 to 1. Additionally, this phenomenon may be due to the stimuli and experimental design. Specifically, when participants encountered noun phrases with a single internationalism, that internationalism was unlikely to be helpful in predicting the second word due to the lack of context. For example, for the stimulus *specjalna ustawa* "special law," it seems implausible that participants could guess the meaning of *ustawa* from

specjalna independent of context, as innumerable other words could be suitable with "special." If this intuition is correct, we see a fruitful direction for further research, as future studies could investigate the importance of not only cognates, but also the context in successful intercomprehension.

The results for word order also expand upon previous research that found only a very modest effect of word order in similar experimental set-ups (Stenger and Avgustinova, 2023). For participants overall, word order did not have a large effect on accuracy, but for participants who were not native speakers of Polish, the NA order was particularly challenging for those who also did not know another Slavic language, as seen in Figure 4. This may imply that at least some participants are not simply translating the two words separately and concatenating them in the correct order, as this strategy would be equally successful for both word orders. This finding represents a notable step toward defining the role of syntactic constructions in intercomprehension.

Among the demographic factors, the effect of knowing another Slavic language is of particular importance. This finding clearly demonstrates that when one has to comprehend and translate from an unknown language, there is great utility in knowing a closely related language. Furthermore, this advantage persists even when translating words that are also broadly shared among more distantly related or unrelated languages, as in the case of internationalisms. In other words, cognates and internationalisms alone may not be sufficient if one's native language is unrelated to the unknown language. However, as noted in Section 3.2, the overwhelming majority of speakers of non-Polish Slavic languages spoke Czech. Czech, like Polish, is a west Slavic language, and therefore, it is possible that this effect would be smaller or absent for speakers of the more distantly related east Slavic languages such as Russian or Ukrainian as well as south Slavic languages like Bulgarian, a conclusion which is arguably consistent with previous findings on intercomprehension for speakers of closely related languages (Gooskens, 2006). Further research could expand on this direction by more explicitly recruiting speakers of a variety of Slavic languages.

6. Acknowledgements

We thank Klára Jágrová for preparing this free translation task experiment. This research was funded by the Deutsche Forschungsgemeinschaft (DFG, German Research Foundation), ProjectID 232722074– SFB 1102 and by Landesforschungsförderungsprogramm Saarland, Project SaarLing.

7. Limitations

In this study, we treated the lexical distance as a simple binary between international vocabulary and all other words. Consequently, this approach ignores cognates, even those that are easily recognized. Furthermore, we did not take into account the level of orthographic similarity between the Polish NPs and English target translations. An approach incorporating both the role of cognates and orthographic distance may have provided a richer picture and may have revealed additional trends in the data.

We presented total response times, which incorporated initial hesitation (i.e. reading), typing and final hesitation (i.e. reviewing or editing one's answer). Unfortunately, a technical error prevented us from successfully recording the latter three measurements. We suspected that this information would have illuminated why there is difference in response times dependent on whether a participant answers correctly or not (see Figure 5) as well as the difference in response time by Polish and other Slavic language speakers.

As a consequence of using two-word noun phrases as stimuli, we only collected data for lexical distances of 0, 0.5 and 1. Stimuli with more words may have allowed us to analyze the effect of lexical distance more finely.

Answers were treated as either entirely right or entirely wrong. Approximate or other intermediate levels of correctness were not considered. For example, incorrect answers included "French men" instead of the target "French man" as a translation of *francuski mężczyzna* and "political opinion" instead of the target "political decision" as a translation of *decyzja polityczna*. Treating answers as being on a spectrum of correctness might have been illuminating, especially for cases of partially or near correct answers.

Participants were invited to take part irrespective of whether they could write proficiently in English, with the result that while the large majority of participants could write competently in English, some could not. In order to study the effect of English writing proficiency in combination with Polish and Slavic nativity, it would be necessary to balance these factors such that we had a larger number of speakers with low English proficiency.

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A. Sensitivity Analysis for Accuracy by Lexical.Distance + Word Order

Table 3: Model with informative priors

	Estimate	Std. Error	L-95% CI	U-95% CI
Intercept	−0.65	0.29	−1.20	−0.07
Lex.Distance	−1.20	0.34	−1.86	−0.53
Word.OrderNA	−0.39	0.20	−0.78	−0.00

Table 4: Model with uniform priors

	Estimate	Std. Error	L-95% CI	U-95% CI
Intercept	-0.63	0.31	-1.24	-0.00
Lex.Distance	-1.29	0.48	-2.23	-0.35
Word.OrderNA	-0.46	0.22	-0.88	-0.01

B. Sensitivity Analysis for Accuracy by Polish.Native + Slavic.Native

Table 5: Model with informative priors

	Estimate	Std. Error	L-95% CI	U-95% CI
Intercept	0.39	0.31	-0.21	1.00
Slav.NatFALSE	-0.71	0.21	-1.12	-0.30
Pol.NatFALSE	-1.56	0.16	-1.87	-1.25

Table 6: Model with uniform priors

	Estimate	Std. Error	L-95% CI	U-95% CI
Intercept	0.68	0.33	0.05	1.33
Slav.NatFALSE	-0.92	0.23	-1.37	-0.48
Pol.NatFALSE	-1.78	0.17	-2.12	-1.45

C. Stimuli

English Target	**Polish Stimulus**
Polish minister	polski minister
new house	nowy dom
European school	europejska szkoła
special law	specjalna ustawa
new day	nowy dzień
American company	amerykańska firma
Polish government	polski rząd
French commission	francuska komisja
new eye	nowe oko
financial state	finansowy stan
public program	publiczny program
Russian president	rosyjski prezydent
political situation	polityczna sytuacja
financial group	finansowa grupa
special water	specjalna woda
private police	prywatna policja
public information	publiczna informacja
Polish money	polskie pieniądze
new month	nowy miesiąc
physical problem	fizyczny problem
French man	francuski mężczyzna
American dad	amerykański ojciec
private thing	prywatna rzecz
political decision	polityczna decyzja
new project	nowy projekt
French community	francuska gmina
new action	nowa akcja
new thousand	nowy tysiąc
Polish mother	polska matka
private hospital	prywatny szpital
new president	nowy prezes
Russian film	rosyjski film
European area	europejski teren
new night	nowa noc
physical topic	fizyczny temat
private number	prywatny numer
special point	specjalny punkt
special percent	specjalny procent
French door	francuskie drzwi

Table 7: English Targets and Polish Stimuli in Adjective-Noun Order

English Target	Polish Stimulus
minister Polish	minister polski
house new	dom nowy
school European	szkoła europejska
law special	ustawa specjalna
day new	dzień nowy
company American	firma amerykańska
government Polish	rząd polski
commission French	komisja francuska
eye new	oko nowe
state financial	stan finansowy
program public	program publiczny
president Russian	prezydent rosyjski
situation political	sytuacja polityczna
group financial	grupa finansowa
water special	woda specjalna
police private	policja prywatna
information public	informacja publiczna
money Polish	pieniądze polskie
month new	miesiąc nowy
problem physical	problem fizyczny
man French	mężczyzna francuski
father American	ojciec amerykański
thing private	rzecz prywatna
decision political	decyzja polityczna
project new	projekt nowy
community French	gmina francuska
action new	akcja nowa
thousand new	tysiąc nowy
mother Polish	matka polska
hospital private	szpital prywatny
president new	prezes nowy
film Russian	film rosyjski
area European	teren europejski
night new	noc nowa
topic physical	temat fizyczny
number private	numer prywatny
point special	punkt specjalny
percent special	procent specjalny
door French	drzwi francuskie

Table 8: English Targets and Polish Stimuli in Noun-Adjective Order