MULTILINGUAL LEARNABILITY AND REACTION TIME IN ONLINE SLAVIC INTERCOMPREHENSION EXPERIMENTS

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Abstract: Receptive multilingualism is a multidimensional and multifactorial phenomenon that crucially depends on the mutual intelligibility of closely related languages. As a strategy, it predominantly capitalizes upon a dynamic integration of linguistic, communicative, contextual, and socio-cognitive aspects. Relevant linguistic determinants (especially linguistic distances) along with recognizable extra-linguistic influences (such as attitude and exposure) have recently enjoyed increased attention in the research community. In our online (web-based) intercomprehension experiments, we have observed learning effects that appear to be empirically associated with individual cognitive skills. For this study, we tested 185 Russian subjects in a written word recognition task which essentially involved cognate guessing in Belarusian, Bulgarian, Macedonian, Serbian, and Ukrainian. The subjects had to translate the stimuli presented online into their native language, i.e. Russian. To reveal implicit multilingual learnability, we correlate the obtained intercomprehension scores with the detected reaction times, taking into consideration the potential influence of the experiment rank on the reaction time too.

Keywords: *online experiments, Slavic intercomprehension, multilingual learnability, reaction time*

1. Background

Processes of globalization and migration pose specific challenges to the way information is transmitted and processed, in which the language factor becomes even more crucial. Notions such as *lingua receptiva* (ten Thije et al. 2017), *intercomprehension* (Doyé 2005), *receptive multilingualism* (Braunmüller, Zeevaert 2001) or *semicommunication* (Haugen 1966) all refer to a communicative practice that reveals the human ability to understand an unknown language on the basis of an already acquired linguistic repertoire, as well as to a *field of study* exploiting linguistic similarities for modeling this special mode of language use. A dynamic process of *mutual intelligibility* may include all kinds of multilingual communication (Rehbein et al. 2012).

Receptive multilingualism involves both *inherent* intelligibility, where readers or listeners of one language are able to understand an unknown related language due to structural linguistic similarities, and *acquired* intelligibility, if they have learnt some (closely) related language (Gooskens 2019). An acquired lingua receptiva can apply to less related or unrelated languages, too (Muikku-Werner 2014); Branets et al. (2019) determine this mode of communication as *mediated* receptive multilingualism. Successful intercomprehension inevitably relies on various types of information: linguistic, communicative, contextual, socio-cognitive, etc. So far, researchers have focused mostly on uncovering variables that influence intercomprehension of related languages (Gooskens, Swarte 2017), with the assumption that the more linguistic similarities two languages share, the higher their degree of mutual intelligibility is expected to be.

Mutual intelligibility of (closely) related languages can be asymmetric. Asymmetries may be of linguistic nature, e.g., if language A has more complicated rules and/or irregular developments than language B, this would result in a structural asymmetry (Berruto 2004). The transparency of vocabularies, along with phonetic, morphological and syntactic structures, is typically asymmetric across Slavic languages (e.g. Jágrová et al. 2017; Stenger et al. 2017; Golubović 2016).

An asymmetric intelligibility can also be due to extra-linguistic factors (e.g. attitude, language exposure) and socio-cognitive aspects (e.g. age, level of education), or 'unequal' language status when speakers of a 'smaller' (or less prestigious) language would understand the 'larger' (or more prestigious) one better than vice versa. Indeed, the relationship between extra-linguistic factors and intelligibility enjoys an increasing attention recently. While some studies found no correlation (Gooskens, Hilton 2013; van Bezoo-

ijen, Gooskens 2007), other registered a positive correlation between attitudes towards a language and its intelligibility (Schüppert et al. 2015; Gooskens, van Bezooijen 2006). Two studies of written and spoken receptive multilingualism (van der Ploeg et al. 2017; Vanhove 2014) investigated the age and the educational level as explanatory variables of observable intercomprehension effects among Germanic languages (Dutch, English, German, Swedish). In particular, van der Ploeg et al. (2017) found that participants with a higher level of education perform better in text intelligibility tests than those with a lower level of education. On the other hand, they did not find the same age-related effects in the written modality as Vanhove (2014), who registered a slight increase across the adult life span. These studies suggest that participants' age would affect both text and word intelligibility scores.

The impossibility to study linguistic processes in the second language acquisition without bringing together the social ('occurring in the world') and the individual ('occurring in one's head') is characteristic for contemporary models of bilingualism (Atkinson 2002). Both inherent and acquired intelligibility imply that social experience is a crucial component of receptive multilingualism, influencing the specific cognitive strategies for understanding an unknown language. Consequently, we need to take into account not only the individual factors influencing the spontaneous understanding of an unknown but (closely) related language but also interlocutors' cognitive skills engaged in this mode of communication. Empirical evidence from a series of written and spoken intelligibility tests is being collected online at the experimental website of the INCOMSLAV project[123], with interfaces in 11 Slavic languages (Belarusian, Bulgarian, Czech, Croatian, Macedonian, Polish, Russian, Serbian, Slovak, Slovenian, and Ukrainian) as well as in English and German. In this contribution, we focus on learnability effects observable in web-based intercomprehension experiments with Slavic languages. In particular, we are interested in a free translation of isolated written stimuli in two East Slavic (Belarusian and Ukrainian) and three South Slavic (Bulgarian, Macedonian, and Serbian) languages by Russian native speakers.

2. The current study

Previous research in mutual intelligibility of Slavic languages shows a generally successful cross-lingual recognition of individual cognates (Stenger 2019; Golubović 2016). With regard to the Cyrillic script, Stenger (2019) reports the following situation, based on the intercomprehension scores from subjects' initial exposure to a cross-lingual cognate guessing challenge in order to avoid any bias and learning effects. Among the East Slavic languages, Ukrainian is more understandable to Russian readers than Belarusian, with the average comprehensibility values for Ukrainian and Belarusian stimuli being relatively high – almost 86% and 73% respectively. For the South Slavic languages, Bulgarian is the most understandable one for Russian readers, with an average comprehensibility value of approximately 71%, followed by Macedonian with 62% and Serbian with almost 59%.

The orthographic distance measured by means of the Levenshtein algorithm appears a good general predictor of intelligibility of an unknown but (closely) related language at the word level in all tested groups. The statistical results also show that the word length as an explanatory variable is essential in the recognition of written South Slavic stimuli by Russian readers since the South Slavic words are generally shorter than their Russian cognates and East Slavic stimuli. Furthermore, Bulgarian and Serbian written intelligibility to Russian native speakers suggests that the higher the neighborhood density (the number of similar words that might interfere in the process of cognate identification), the lower the number of successful translations although this is not the case for Ukrainian, Belarusian, and Macedonian stimuli when presented to Russian readers. However, according to the experimental results, the frequency of cognates is not a reliable predictor for Russian readers.

In our investigation with Russian subjects, we examine the chance of their good performance in five related languages as *implicit multilingual learnability*. Participants are quite likely to develop implicit skills in 'learning by doing' (Beerkens 2010) to reach a better understanding of a related language. Previous studies on receptive multilingualism investigate the phenomenon of 'learnability' (*explicit* and *implicit*) mostly between two closely related languages or via a 'bridge' language. While some research

[123] https://intercomprehension.coli.uni-saarland.de/en/

has shown that dedicated teaching intervention may give results (cf. Branets et al. 2019; Golubović 2016), other studies indicate no significant improvement (cf. Bergsma et al. 2014).

According to the approach of Kleinschmidt and Jaeger (2015), which includes (1) recognizing previously encountered situations, (2) generalizing to other situations based on previous encountered situations, and (3) adapting to novel situations, we hypothesize that there is a link between the implicit multilingual learnability based on experiment ranking and the individual word recognition. In testing the intelligibility between closely related languages, the reaction time can be a sensitive response measure if the test language is very similar to the language of the subjects and the most answers are correct. The assumption here is that the faster the subjects react, the better the intelligibility (cf. Gooskens 2013). In other words, the intelligibility of a stimulus interacts with the reaction time needed for processing it. More specifically, we assume that the rank of a given experiment, which corresponds to the order of its presentation to an individual subject, has an impact on the intelligibility and will correlate positively with good word recognition abilities. On the other hand, the time needed for completing a written translation task will correlate negatively with the rank of experiment.

To detect multilingual learnability effects in connection with reaction time in web-based intercomprehension experiments, we address here the following questions: (i) How well do Russian readers understand cognate words of unknown but related languages – East Slavic (Belarusian and Ukrainian) and South Slavic (Bulgarian, Macedonian, and Serbian)? (ii) What is the relation between performance and reaction time in reading intercomprehension? (iii) How does the experiment rank influence the performance of readers' groups? (iv) What is the link between the experiment rank and reaction time?

We start by providing relevant information about the experiments and the participants (Section 3), then we go on to present the results and the analysis (Section 4), and finally we draw some general conclusions (Section 5).

3. Experimental setup

3.1. Testing material

The Belarusian (BE), Bulgarian (BG), Macedonian (MK), Russian (RU), Serbian (SR), and Ukrainian (UK) data used in this work come from a collection of parallel word lists of internationalisms and Pan-Slavic vocabulary, which were freely available from the EuroComSlav project[124], as well as cognates[125] from Swadesh lists[126] and from Common Slavic vocabulary (Carlton 1991). The linguistic items in these lists belong to different parts of speech, mainly nouns, adjectives, and verbs. We have manually designed a cross-linguistic rule set of matching orthographic units (transforming both individual characters and character strings) based on traditional comparative-historical Slavic linguistics. This resulted in linguistically informed rules and diachronically motivated orthographic correspondences (from Proto-Slavic to modern Slavic languages), e.g. BG–RU: *б*:*бл*, *ж*:*жд*, *ла*:*оло*, *я*:*е*, etc. In a computational transformation experiment (Fischer et al. 2015) we have applied this rule set to the parallel word lists and categorized all cognates in the respective pairs as either (i) identical, or (ii) successfully transformed, or (iii) non-transformable by the rule set. The selection of stimuli for our web-based experiments includes correctly transformed items (ii)[127].

3.2. Procedure

The cross-lingual intelligibility was tested by means of a free translation experiment with isolated written stimuli (single words) at the experimental website of the INCOMSLAV project[128]. The participants started the experiment with registration and then completed a background questionnaire in their native

[124] Cf. Angelov (2004) and Likomanova (2004).
[125] That is, historically (etymologically) related word pairs that still bear the same meaning in both languages.
[126] Slavic Swadesh lists.
[127] The word lists with rule sets are online available in Stenger (2019: appendix 2–6).
[128] https://intercomprehension.coli.uni-saarland.de/en/

language (RU). After that, 6 challenges with 340 items (in total) were presented randomly: 2 challenges with 60 different BG stimuli in each group, 1 challenge with 60 UK stimuli, 1 challenge with 60 BE stimuli, 1 challenge with 50 MK stimuli, and 1 challenge with 50 SR stimuli. The order of the stimuli was randomized. The participants saw the stimuli on their screen, one by one, and were given 10 seconds to translate each word into RU. The time limit was carefully chosen, taking into consideration the experience of other experiments in reading intercomprehension (Golubović 2016). The allocated time limit seemed to be sufficient for typing even the longest words but not long enough for using a dictionary or online translation tools. It was possible to finish before the 10 seconds were over by either clicking on the 'Next' button or pressing 'Enter' on the keyboard. After 10 seconds the participants saw the next stimulus on their screen. An immediate feedback was given in the shape of an emoticon on the left at the bottom of the page – a thumb up for a successful translation or a sad face for a wrong or missing translation. The output was automatically categorized as 'right' or 'wrong' via pattern matching with pre-defined expected answers. Some stimuli had more than one possible translation. We also provided a list of so-called alternative correct answers. For example, the BG word *път* (*pat*) "way"[129] can be translated in RU as *путь* (*put'*) or *дорога* (*doroga*), so both translations were counted as correct. The responses were then manually checked for typographical errors in the final analysis.

3.3. Participants

The subjects were recruited for participation in the experiment mainly through universities and social media. In total, 185 RU speakers (141 female, 43 male and 1 not specified; aged between 14 and 71 years, i.e. average age was 30.5) took the written word recognition test in the five related languages (BE, BG, MK, SR, UK).

Table 1. Number of participants in experiments per language

Languages	Number of participants
Belarusian	57
Bulgarian	103
Macedonian	58
Serbian	68
Ukrainian	62

Here, we are interested in *inherent* intercomprehension, which relies on language features available to interlocutors prior to language learning because of the close relationship between the two languages (cf. Gooskens 2019). Therefore, only participants who speak RU natively and who do not know the stimulus language have been included in the following analysis. As already mentioned above, the language the experiment was to be taken in, was randomly assigned to the subjects. The participants could do more than one experiment in the respective languages, for example, the first experiment in UK (ranked 1), the second in BE or in BG[130] (ranked 2), etc. We analyze here only the first four ranks[131] of experiments because the number of participants in rank 5 was low and not evenly distributed across the languages. Table 1 shows how many RU participants took part in four ranks of experiments in the respective language.

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[129] The BG word *път* (*pat*) has one more translation into RU: the phrase *два пъти* (*dva pati*) means *два раза* (*dva raza*) "twice" in RU.

[130] There were two challenges in BG with different 60 cognates in each challenge. We consider participants only with initial BG challenge in order to exclude the learning effect within one language.

[131] Ranks mean the presentation order of experiments.

4. Discussion of results

Three types of empirical data obtained from the conducted web-based intercomprehension experiments show potential to reveal the implicit multilingual learnability we are interested in here – namely, intelligibility scores, reaction time, and experiment rank. Below we scrutinize their interaction.

4.1. Intelligibility score and reaction time

We calculated intelligibility scores as percentages of correct word translations for each subject per stimulus language. The mean percentage of correctly translated items constitutes the intelligibility score of a given language (see Table 2). In addition to the intelligibility scores, we measured reaction time in ms. (including the initial hesitation time, typing time and final hesitation time before clicking on 'Next') per stimulus[132], using the functionality of the experimental website. The mean reaction time per participant was calculated on the basis of correct translations only.

Table 2. Intelligibility scores achieved by Russian readers

Languages	Intelligibility scores
Belarusian	82%
Bulgarian	75%
Macedonian	71%
Serbian	68%
Ukrainian	88%

The findings show that UK is more intelligible for RU readers than BE (all three languages belong to the East Slavic group). BG occupies the third position with regard to intelligibility followed by MK and finally SR (all three languages belong to the South Slavic group). The comprehension order of the five Slavic languages among RU participants is in line with Stenger's (2019) findings, who investigated the impact of linguistic factors (e.g. orthographic distance, word length and frequency as well as neighborhood density[133]) on Cyrillic script intelligibility, taking into consideration just the initially completed challenge for each subject.

The linear interaction between the reaction time and the intelligibility scores was negative and significant in all language groups. Table 3 provides an overview of the statistical results (Pearson's r and p-value). Though the negative correlations can be considered from low to middle, the participants with better performance seem to complete the individual word translation task faster.

Table 3. Correlations between reaction time and intelligibility scores per language

Languages	Statistical results
Belarusian	$r = -0.43$, $p < 0.001$
Bulgarian	$r = -0.36$, $p < 0.005$
Macedonian	$r = -0.34$, $p < 0.01$
Serbian	$r = -0.58$, $p = 2.40e\text{-}07$
Ukrainian	$r = -0.43$, $p < 0.0005$

[132] Mean word length was distributed in the analyzed material as follows: BE(5.03) – RU(5.22), BG(4.61) – RU(5.09), MK(4.16) – RU(4.62), SR(4.10) – RU(4.66), UK(4.80) – RU(4.75).

[133] Neighbors are similarly written words in the target language that might interfere in the process of cognate identification of the stimulus.

4.2. Experiment rank and intelligibility scores

In Section 4.1, we have compared the participants of all experiment ranks within a language group. As a next step, we need to investigate the interaction of intelligibility scores and reaction time depending on the experiment rank.

Table 4. Correlations between intelligibility scores and experiment rank per language

Languages	Statistical results
Belarusian	$r = 0.45$, $p < 0.0005$
Bulgarian	$r = 0.20$, $p < 0.05$
Macedonian	$r = 0.50$, $p = 6.79e\text{-}05$
Serbian	$r = 0.49$, $p = 2.61e\text{-}05$
Ukrainian	$r = 0.29$, $p < 0.05$

To investigate the performance of RU subjects in Slavic intercomprehension depending on the order in which they complete a given challenge, we correlated the intelligibility scores with the experiment rank in the respective language group. We found a positive and significant correlation in all language groups, though the positive correlations for BG and UK are rather low – cf. Pearson's *r* and *p*-value in Table 4. This means that the rank of the experiment has an impact on the intelligibility in Slavic reading intercomprehension. In addition, we calculated the mean success rate per experiment rank in all language groups. Figure 1 shows the chance of good performance among RU readers per experiment rank in the respective language.

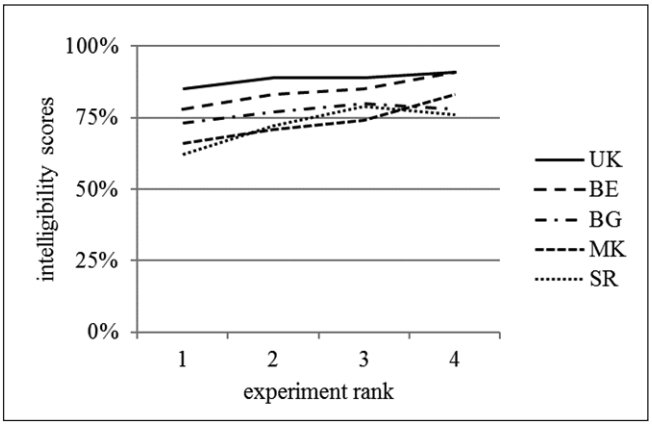

Figure 1. Intelligibility scores per experiment rank and per language

For UK stimuli we see that the participant groups seem to improve through all four ranks although there is no difference in the intelligibility scores between rank 2 (89%) and rank 3 (89%). For BE stimuli we see that the participants keep improving step by step according to the experiment rank. The BE group of rank 4 reaches the best performance of 91%, quite like the UK group of rank 4.

Participants taking the test in BG obtain lower score than in UK and BE in all experiment ranks. However, they keep improving by experiment rank 3 (80%), after which the performance of rank 4 declines slightly (78%). The same holds for SR stimuli (compare 79% for rank 3 and 76% for rank 4) although the performance of the participants in all experiment ranks is poorer than in BG.

Looking at MK stimuli, we see that the chance of good performance increases from rank to rank, similarly to BE. However, the performance in MK is lower than in East Slavic languages altogether. If we compare the intelligibility scores for MK and SR stimuli according to the experiment rank, the participants in rank 1 and rank 4 are more successful in translating MK stimuli. Nevertheless, in rank 2 and rank 3,

the subjects show better performance in the perception of SR stimuli. In general, BG seems more intelligible for RU readers than MK (until rank 4) and SR. This can be explained by the fact that the graphic-orthographical system of BG is more similar to the RU system than to the MK and the SR systems (cf. Stenger 2019).

An important note to be made here is that the data of rank 4 are based on a rather small number of subjects per language (between 5 and 9 participants in all languages) and must therefore be interpreted with caution.

4.3. Experiment rank and reaction time

First, we correlated the mean reaction time per participant with the experiment rank and found a negative and significant correlation in all language groups – cf. Table 5 (Pearson's r and p-value). This means that the experiment rank has an impact on the reaction time. The participants complete the translation task faster depending on the rank.

Table 5. Correlations between mean reaction time per participant and experiment rank per language

Languages	Statistical results
Belarusian	$r = -0.35$, $p < 0.01$
Bulgarian	$r = -0.34$, $p < 0.0005$
Macedonian	$r = -0.27$, $p < 0.05$
Serbian	$r = -0.45$, $p < 0.0005$
Ukrainian	$r = -0.35$, $p < 0.01$

Additionally, we calculated the mean reaction time per experiment rank in all language groups (see Figure 2).

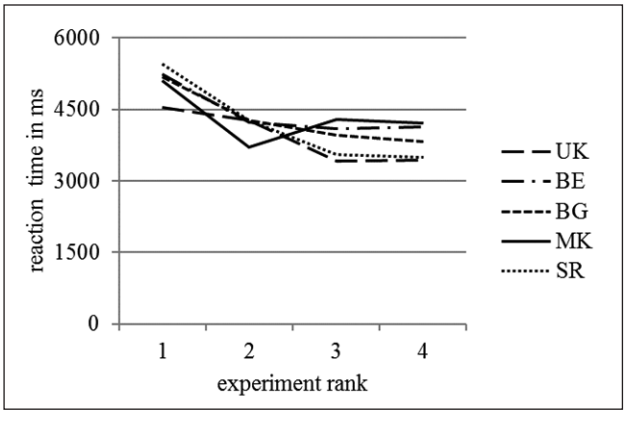

Figure 2. Reaction time per experiment rank and per language

An interesting finding here is that four languages BE, BG, SR, and UK show similar patterns in the mean reaction time per participant's rank. This means that subjects react faster according to the rank, with a minor exception for UK – compare rank 3 (3417 ms) and rank 4 (3436 ms), as well as for BE – compare rank 3 (4105 ms) and rank 4 (4133 ms). In general, it seems that participant groups are faster in translating UK stimuli than BE, BG, and SR stimuli. In addition to the high intelligibility scores (see Section 4.2), this suggests that not only do RU subjects understand UK better, but that they find the right answer even faster. It is also remarkable that though the participants of rank 3 and rank 4 were more successful in translating from BE than from BG and SR, they spent in these ranks slightly more time in correctly translating BE stimuli than BG and SR stimuli. Looking at MK, we see that the participant group in rank 2 is faster (3710 ms) than in rank 3 (4282 ms) and rank 4 (4204 ms). The explanation may lie in the socio-demographic factors (age, level of education, language repertoire) of the respective participants' groups.

5. Conclusions

Receptive multilingualism as a multidimensional and multifactorial phenomenon depends on the mutual intelligibility of closely related languages. Relevant linguistic determinants (especially linguistic distances) along with recognizable extra-linguistic influences (such as attitude and exposure) have recently enjoyed increased attention in the research community investigating this dynamic strategy. The subjects themselves, their individual characteristics and their motivation in comprehending an unknown but (closely) related language play an important role, too. That is why in investigating the basics of mutual intelligibility, any learning effects are rather unwanted. Thus, the same respondent should not hear or read the same stimulus twice (Gooskens 2013; Gooskens et al. 2008), even though – as Gooskens (2013) points out – this contradicts the fact that it is desirable to use the same material when comparing the intelligibility of more languages.

In our current investigation, the stimuli presented in online experiments are based on the selection of items with diachronically motivated orthographic correspondences. All five tested languages with 340 items (in total) share only five stimuli that correspond to the same RU cognates. Two East Slavic languages, UK and BE – with 120 stimuli (in total) in both languages – have 27 stimuli with the same RU cognates, but all 27 UK and BE stimuli are orthographically non-identical. The three South Slavic languages – BG, MK, and SR – with 220 tested stimuli list 22 stimuli with the same RU cognates, of which 13 are orthographically identical in all three languages. Even though the language in which the experiment was to be taken was randomly assigned to the subjects, the participants seem to develop – quite in accord with previous findings (Kleinschmidt, Jaeger 2015) – appropriate cognitive skills from experiment to experiment in recognizing, generalizing, and adapting encountered diachronically motivated orthographic correspondences to novel situations multilingually and improve their performance in intercomprehensive reading. The three pillars approach supported here consists of motivating the participants (i) during the experiment by immediate feedback, (ii) at the end of the experiment with visualization of the overall results, and (iii) by awarding a medal as an incentive to continue the language game.

The general conclusion that we can draw from our investigation is that implicit multilingual learnability based on the experiment rank has an impact on intelligibility and reaction time in the comprehension of an unknown but (closely) related language. In this study we reported results of free translation cognate guessing experiments with isolated written stimuli of two East Slavic (BE and UK) and three South Slavic (BG, MK, and SR) languages presented to RU native speakers. We found that, among the East Slavic languages, UK is more intelligible for RU readers than BE. Furthermore, BG occupies the third position and, among the South Slavic languages, is understood better than MK and SR. According to our findings, the participants with better performance tend to complete the individual word translation task faster. In general, the intelligibility scores increase according to the experiment rank in all languages. The mean reaction time needed for completion of a written translation task experiment correlates negatively and significantly with the experiment rank in the respective related language, although to a low and middle degree. Our results thus shed light on spontaneous good performance of subjects focusing on their individual cognitive skills, which reveals implicit multilingual learnability based on the experiment rank and reaction time. A natural extension of the study is to include other Slavic language pairs as well as socio-demographic factors such as age, gender, language repertoire, level of education, and professional background. Another research direction is to investigate the influence of socio-cognitive factors on text intelligibility in different modalities, e.g., written vs. spoken. In such a way, we will gain better insights into the spontaneous performance of interlocutors in an intercomprehension scenario.

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МЕЖДУЕЗИКОВА ОБУЧАЕМОСТ И ВРЕМЕ ЗА РЕАКЦИЯ В ОНЛАЙН ЕКСПЕРИМЕНТИ ПО СПОНТАННО РАЗБИРАНЕ НА СЛАВЯНСКИ ЕЗИЦИ

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Резюме: Рецептивното многоезичие е многоизмерно и многофакторно явление, което в решаваща степен зависи от взаимната разбираемост при близкородствени езици. Като стратегия то включва динамична интеграция на езикови, комуникативни, контекстуални и социокогнитивни аспекти. Засилено внимание в научните среди привличат както лингвистичните детерминанти, базиращи се на езикови дистанции, така и извънлингвистичните влияния, отразяващи субективна нагласа и езикова експозиция. В проведените от нас онлайн експерименти за спонтанно разбиране на славянски езици в писмена форма наблюдаваме ефекти на обучение, емпирично свързани с индивидуални когнитивни умения. На 185 рускоезични участници бяха представени подборки от сродни думи на беларуски, български, македонски, сръбски и украински, като задачата им бе да преведат съответните стимули на майчиния си език, т.е. на руски. Регистрираното индивидуално време за реакция бе съпоставено както с качеството на получените отговори, така и с ранга на експеримента по отношение на последователността при представяне на езиците. Целта е установяване на потенциални обучаващи ефекти в дадената многоезична ситуация.

Ключови думи: *онлайн експерименти, спонтанно разбиране на славянски езици, междуезикова обучаемост, време за реакция*

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