Trilingual spoken word recognition

Interlingual competition from one or two non-target languages in a sentence context

Yulia Kashevarova

Centre for Research on Bilingualism
Department of Swedish Language and Multilingualism

Master's Degree Project

Spring 2023

Supervisor: José Alemán Bañón

Stockholms universitet

Trilingual spoken word recognition

Interlingual competition from one or two non-target languages in a sentence context

Yulia Kashevarova

Abstract

Persistent non-target language co-activation in spoken and visual language comprehension has been found both at the word-level and at the level of a sentence, although in the latter case, sentence bias has been observed to modulate the co-activation which can create lexical competition. In the case of trilingual speakers, both non-target languages may potentially compete with the third language (L3). The current study aimed to investigate how cross-linguistic (or interlingual) competition across three languages is modulated by sentence bias while listening to the L3. Of particular interest was whether top-down sentential information would modulate not only single but also double bottom-up driven cross-linguistic competition.

A picture-word recognition task was given to 44 L1 Russian L2 English late L3 Swedish learners, listening to Swedish sentences online while their reaction times and accuracy were collected. The results revealed shorter processing times and higher accuracy for high- compared to low-constraint sentences and overall lower accuracy (and slower reactions in high-constraint sentences) when an L1 Russian competitor's translation phonological onset overlapped with a Swedish target word. The findings suggest that when trilinguals were processing their L3 speech, top-down information from the sentential context did not modulate the bottom-up guided L1 phonological competition. However, the effect of an L2 English L3 Swedish cognate competitor was not significant. This pattern of results is in line with BLINCS (Shook & Marian, 2013), which assumes gradual co-activation decay (i.e., a strong cross-linguistic competition effect might be observed in the end-course reaction times) and a direct visual information influence on linguistic processing. It is, however, inconsistent with the BIA+ model (Dijkstra and Van Heuven, 2002), which predicts that a high-constraint sentence context can modulate cross-linguistic competition, particularly, at later processing stages.

Keywords

Trilingual speech processing, cross-linguistic competition, sentence context, BLINCS, BIA+.

Trespråkig igenkänning av talat ord

Tvärlingvistisk konkurrens från ett eller två icke-målspråk i en meningskontext

Yulia Kashevarova

Abstrakt

Ihållande samaktivering av icke-målspråk i talad och visuell språkförståelse har hittats både på ordnivå och på meningsnivå, även om i det senare fallet har meningsbias observerats för att modulera samaktiveringen som kan skapa lexikal konkurrens. När det gäller trespråkiga talare kan båda icke-målspråken potentiellt konkurrera med det tredje språket (L3). Den aktuella studien syftade till att undersöka hur den tvärlingvistiska (eller interlinguala) konkurrensen mellan tre språk moduleras av meningsförspänning när man lyssnar på L3. Av särskilt intresse var huruvida top-down meningsinformation skulle modulera inte bara enstaka utan också dubbel-bottom-up-guidade tvärlingvistisk interferens.

En bild-ordsigenkänningsuppgift gavs till 44 L1 ryska L2 engelska senlärda L3 svenska talare, som lyssnade på svenska meningar online medan deras reaktionstider och noggrannhet samlades in. Resultaten avslöjade kortare bearbetningstider och högre noggrannhet för meningar med hög jämfört med meningar med låg begränsning och lägre noggrannhet (och långsammare reaktioner i meningar med hög begränsning) totalt när en L1 rysk konkurrents fonologiska översättningsstart överlappade ett svenskt målord. Resultaten tyder på att när trespråkiga bearbetade sitt L3-tal, modulerade top-down information från sententiella sammanhang inte den bottom-up guidade L1 fonologiska konkurrensen. Effekten av en L2 engelsk L3 svensk besläktad konkurrent var dock inte signifikant. Detta resultatmönster är i linje med BLINCS (Shook & Marian, 2013), som förutsätter ett gradvis samaktiveringsförfall (dvs. en stark tvärlingvistisk konkurrenseffekt kan observeras i slutförloppets reaktionstid) och en direkt visuell informationsinflytande på språklig bearbetning. Det är dock oförenligt med BIA+ (Dijkstra och Van Heuven, 2002) som förutsäger att en meningskontext med hög begränsning kan modulera tvärspråklig konkurrens, särskilt i de senare bearbetningsstadierna.

Nyckelord

Trespråkig talbehandling, tvärlingvistisk konkurrens, meningskontext, BLINCS, BIA+.

Acknowledgements

I would like to express my deepest gratitude to all the participants who kindly and enthusiastically devoted their time and energy to take part in various tasks of the project. Your willingness to contribute and desire to learn were encouraging and inspiring. I would like to thank Lada, my reliable Russian friend, who helped me on the way enormously. My Russian and Swedish families have been incredibly supportive and understanding throughout the course of the study. Thank you for making me feel stronger and believing in me devotedly and lovingly. I owe eternal gratitude to my supportive and patient life partner, Swedish language and IT expert, Mattias. Not only did you help by listening to my talks about brains, languages, and statistics, but you also encouraged me to pursue my goals, stay realistically positive and take breaks on the way.

I feel extremely fortunate to have had the opportunity to be supervised by Dr. José Alemán Bañón. Thank you so much for the inspiration and knowledge you shared, for the time you devoted and always topical and thorough feedback you gave. I am also grateful for your seminars and discussions we had during them. Most of all, I would like to thank you for one question at the very beginning of the project. You asked me which of the several ideas that I had were most interesting for me. You showed the same encouragement at different stages of the project.

Finally, I would like to thank Anna for giving a beautiful clear voice to my sentence, making them not only experimentally meaningful but also pleasant to work with. Your patience and reliability go beyond any expectations. I also owe my gratitude to all those people who listened to me and gave advice while I was developing and running the experiment.

Contents

1. Introduction

When a multilingual speaker hears a sentence in their non-native language, the process of word recognition is so fast that it may seem unthinkable that, to be selected, a word has to compete against other lexical items within its own and across other languages the speaker knows (Shook & Marian, 2019). The more similar the words sound, the more competition there is (Lagrou et al., 2013b), which results in the brain taking longer to select or process and integrate such words. Consistent cross-linguistic competition regardless of the input language has led to the conclusion that lexical access to an integral semantic store is non-selective, meaning that the top-down processes guided by the preceding context information cannot completely or unconditionally eliminate this bottom-up guided interference (Duyck, 2007). Understandably, the complexity of mental lexicon organisation increases with additional languages.

Moreover, such complexity has consequences. On the one hand, it has been suggested that the need to manage several languages can allow multilingual speakers to become better at doing general executive control tasks especially for older bilinguals (Bialystok, 2009 but see Duñabeitia et al., 2014); provide a bigger cognitive reserve to older adult trilingual compared to bilingual speakers (Schroeder & Marian, 2017); and make multilinguals better at decision-making (Keysar et al., 2012). Furthermore, bilingual learners have been shown to acquire another non-native language more easily than initially monolingual speakers (Szubko-Sitarek, 2015).

On the other hand, along with the positive findings supporting the bilingual cognitive advantage, numerous studies have failed to obtain compatible results (Duñabeitia et al., 2014; Antón et al., 2016). Furthermore, sharing one brain's capacity across several languages means using each lexical item less frequently and accurately, potentially, building weaker lexical connections as captured by the weaker links hypothesis (Gollan et al., 2008; 2011; but see Bylund et al. (2022) for the language learning history account). It also requires resolving the competition from similar words within and across languages, which altogether can make word retrieval less efficient (Spivey & Marian, 1999), resulting in processing delays and difficulties in comprehension (Shook et al., 2015; Dijkgraaf et al., 2019).

Several studies on auditory sentence comprehension have found that, although the general processing pattern does not differ across monolingual and L1 or L2 listening bilingual groups, bilinguals tend to be slower and show weaker lexical access in both of their languages (Shook et al., 2015). Unsurprisingly, the more languages added into one mental lexicon, the more factors that come into play (e.g., proficiency, the age of acquisition and use of each language), and cross-linguistic competition might also increase as a result of a bigger number of interfering items. Several studies have used a word recognition task to explore interlingual competition and understand whether and to what extent it may be modulated by top-down information, provided by the task demands or sentential context.

At the word-level, it has been repeatedly found that top-down context information cannot completely eliminate the influence of bottom-up visual and auditory information (provided by the strings of sounds or letters), but the scope of this influence can be modulated by the preceding linguistic context (e.g., the language of instructions or texts read before the task), which, in its turn, can be affected by, e.g., language status or L2 proficiency (Van Hell & Dijkstra, 2002; Marian & Spivey, 2003; Spivey & Marian, 1999).

At the same time, parallel language activation can create a facilitative effect by priming the following word through bottom-up co-activation due to the form overlap (Carreiras et al., 2005). Moreover, cases of extreme cross-linguistic similarity, e.g., cognates, words which share both form and meaning (Sunderman & Schwartz, 2008), have demonstrated a robust facilitative effect (faster reaction times and higher accuracy rates). This facilitation effect can become cumulative for trilinguals, processing cognates sharing the status across three compared to two languages (Lemhöfer et al., 2004; Szubko-Sitarek, 2011). Although the cumulative cognate effect has shown to depend on the speakers' L3 proficiency, once visible, it appears to stay robust regardless of the prior language context (Van Hell & Dijkstra, 2002).

While cross-linguistic co-activation has been observed to be persistent at the single-word level in both visual and spoken modalities, sentential context studies have found diverging results. In sentences, interconnected words create another level of meaning, which, along with the single-word interpretations, can be guided by speakers' context-based expectations and predictions, which appear to interact with word-level processes. In order to understand the relation between a sentence context and cross-linguistic co-activation, several studies have explored the recognition of interlingual cohorts, homophones or cognates in semantically low (providing no bias towards any word) and highly constraining (biasing towards a target) sentences.

It has mostly been found that the semantically low-constraint sentence context is not able to significantly modulate cross-linguistic co-activation, but the results for constraining sentences and/or later processing stages diverge. While in some cases, the cross-linguistic competition was modulated by the high-constraint sentence context (Chambers & Cooke, 2009), in others, the modulation was not significant (Lagrou et al., 2013a, b). In a seminal study, Van Assche et al. (2011) (replicated by Kurnik (2016)), observed a robust cognate facilitation effect in both context conditions, similarly to Dijkstra et al. (2015).

In general, the interaction between cross-linguistic co-activation and sentential context appears to be sensitive to such factors as the language of input (native or nonnative) (Shook et al., 2015), the degree of cross-linguistic similarity (Van Assche et al., 2011), the level of semantic constraint (Chambers & Cooke, 2009), the task (Lijewska, 2022), the critical words' lexical properties (e.g., concreteness) (Van Hell & de Groot, 2008), and the processing stage (Libben & Titone, 2009).

Crucially, most of the findings are limited to bi-, not multilingual language processing, leaving open the question of how and whether adding one more language may change the situation. Research on trilinguals, to date, is vastly restricted to single-word processing and third-language acquisition. The results of the few studies in the field suggest that it might be possible to apply some knowledge about bilingual language processing to multilingual speakers (Blank & Llama, 2019). However, more research is needed to understand to what extent and regarding which factors such generalisation is possible, because there is also evidence of differences between the two populations, e.g., with respect to the time-course of the use of sentential semantic cues or the cognate facilitation effect, which has not always been found for trilingual speakers (Lijewska, 2022).

Possibly one of the most important findings on trilingual word recognition is that, similarly to bilinguals, their lexical access is also nonselective (Lemhöfer et al., 2004; Bartolotti & Marian, 2018). As mentioned above, cross-linguistic co-activation can be accumulated across three languages (Lemhöfer et al., 2004; Szubko-Sitarek, 2011) and, similarly to bilinguals, it can be driven by covert co-activation of lexical items, occurring due to the translation equivalents' form similarity, without any direct form overlap with the input (Bartolotti & Marian, 2018; Shook & Marian, 2019).

However, the recent and, seemingly, unique-to-date, study on 'triple' cognate recognition in low- and high-constraint L3 (or L2 for some participants) sentences by Lijewska (2022) failed to observe the cognate facilitation effect regardless of sentence constraint, which is inconsistent with the research on bilinguals. Crucially, there seems to be no research on trilingual word recognition in spoken sentences. Although orthographic and phonological overlap effects have been shown to interact (Shook & Marian, 2013), there are crucial differences between spoken and written language comprehension which make speech processing arguably more complex than reading. For example, one difference concerns the sequential and instantaneous nature of speech, compared to the whole-piece-present written word. Thus, the findings regarding written language may not necessarily be applied to speech comprehension.

A large and possibly increasing number of trilingual speakers in the world and in Sweden, in particular, on the one hand, and the scarcity of the research on this population, on the other, make trilingual speakers an important group to explore. Additionally, research on multilinguals provides new opportunities for an experimental set-up in which the relative effect of several factors can be captured within one framework. For instance, little is known about how a sentential context modulates cross-linguistic competition, enhanced by the coactivation of multiple-languages, spread across various representational levels (e.g., phonological and/or semantic). Finally, addressing more language combinations expands knowledge in the field, in particular, regarding the effect of cross-lingual similarity, known to affect language processing and acquisition (Alemán Bañón & Martin, 2021; Bardel & Falk, 2007).

The current study investigates how cross-linguistic competition of varying degrees (between two or three languages) and kinds (overt L1-L3 phonological and covert L2-L3 cognate interference) interacts with the low- or high-constraint L3 spoken sentence. In particular, the question is whether the overt-covert cross-linguistic competition becomes cumulative, resulting in the modulation or elimination of the high-constraint sentence effect. For these purposes, 44 L1 Russian L2 English late L3 Swedish learners, living in Sweden, were given a task to recognise spoken words in Swedish low- and high-constraint sentences, while, in the critical trials, target words phonologically overlapped with competitors' Russian translations, whose English equivalents were English-Swedish (non)cognates. The process through which an additional L2-L3 cognate effect may occur is discussed within the BLINCS model account of cascaded overt and covert co-activation (Shook & Marian, 2013) while the interaction between the top-down sentence context effect and bottom-up driven cross-linguistic competition is also discussed within the BIA+ model (Dijkstra and Van Heuven, 2002).

2. Theoretical framework

2.1 Speech processing

Speech is the earliest form of language we learn. Further in life it develops to create possibly the most frequent way of expressing and comprehending a language in both monolingual and multilingual environments (Grosjean, 2013). Speech comprehension involves fast and automatic decoding of an acoustic signal into meanings through mental functions, serving to retrieve words, which are normally embedded into sentences, situated in a contextualised discourse (Dahan & Magnuson, 2006). Importantly, while this process does not require any additional knowledge of how to write or read, it is, in fact, extremely complex in its core (Cutler, 2012).

To begin with, speech components are instantaneous and disappear in their perceived form immediately. Furthermore, a phonological form is not the only representation of a spoken word. In order to retrieve the item's meaning and situate it into a given context, brains have to involve their phonological memory which retains the received information while the item's syntactic and lexico-semantic information bits are being analysed (Vallar, 2001). Moreover, since the spoken language unfolds over time, new information becomes available sequentially, making it necessary to update meaning-retrieval-decisions.

Natural speech does not usually consist of single words but rather utterances. Understanding those utterances involves recognising the embedded words separately and as a whole. For this purpose, the received auditory input is mapped onto representations of words, stored in the speaker's mental lexicon (Weber & Scharenborg, 2012).

Seemingly effortless, the mapping process with the following retrieval of a relevant item is complex even within one language. Certain features of speech are responsible for this.

Firstly, "even slow speech is fast" (Cutler, 2012: 33), considering how much changing and diverse information needs to be processed. Secondly, different words resemble each other (e.g., *bone, boat, bowl,* pronounced in British English as /bəʊn/, /bəʊt/, and /bəʊl/[1], differ in one final phoneme only). This happens because a potentially infinite number of words is composed of a finite number of phonemes within a language (Cutler, 2012: 48; Weber & Scharenborg, 2012). Thirdly, speech is variable across communities speaking a language and even within one community. The speaking rate and style can differ depending on the context surrounding a phoneme, e.g., in the process of assimilation, some phonemes may disappear like /p/ from *cup* /kʌp/ in *cupboard* /ˈkʌbərd/. Lastly, the continuous and transitory nature of speech co-exists with the fact that boundaries for every word are not strictly defined (Cutler, 2012: 35). Consequently, a listener has to have enough perceptual experience to know the borders of each word, and how various lexical items interact in a given language (Massaro, 2001). To make things even more complicated, parts of longer words can be perceived as smaller words, e.g., *ant* /ænt/ "is embedded in *began to*" /biˈæntə/ (Weber & Scharenborg, 2012: 387) and longer words can be composed of several smaller words, e.g., Swedish *jordgubbstårta* (strawberry pie) consists of three shorter words: *jord* (earth), *gubbe* (old man) and *tårta* (pie).

On top of the above difficulties, lies the complexity of the process of spoken word recognition, which implies matching the received auditory input with a mental representation chosen as best suited among similar word candidates (Dahan & Magnuson, 2006: 251). Frauenfelder and Tyler (1987) describe three crucial stages of word recognition. The first *contact phase* occurs when an acoustic signal is recognised as speech, triggering the activation of possible competing lexical candidates. It is then followed by the *selection* stage, during which these candidates are evaluated in relation to the sensory input, and the final *integration* phase considers the remaining candidates against verbal and nonverbal contexts. The information from the contexts, including the interlocutor's background, a place and topic of a conversation is called "top-down" while strings of phonemes, i.e., phonological input, provide "bottom-up" information (Grosjean, 2013: 37). The interaction between top-down and bottom-up information is captured by psycholinguistic models of word recognition.

Numerous studies have found that the degree of the lexical items' competition during the selection phase is relative to their similarity to the input and their frequency of use (Dahan et al., 2001; McDonald & Kaushanskaya, 2020). Among the strongest similarity options are the shared phonological onset (Weber & Cutler, 2004) and rhyming (Desroches et al.,

---

[1] Slashes /…/ are used for abstract phonemic notations (including only features that are distinctive in a language) and square brackets […] reflect phonetic, more detailed, actual pronunciation (Handbook of the International Phonetic Association, 1999).

2009). The competition also increases with a bigger number of phonological neighbours, words differing in few phonemes (Garlock et al., 2001). Word recognition efficiency additionally depends on how well the received acoustic-phonetic information matches the representations stored in the brain (Weber & Scharenborg, 2012), although it has been found that listeners can accommodate to their interlocutor's speech behaviours or the acoustic signal context (Pisoni, 2017; Pardo, 2010).

Finally, the word recognition process is complete when one candidate is successfully selected and integrated into the context. It has been found that when listening to L1 speech, the brain is able to generate predictions about forthcoming information by using various contextual cues, as evidenced by shorter reaction times or more eye-gazes on predicted items in constraining sentential contexts (Kaan, 2014; Kuperberg & Jaeger, 2016; Tanenhaus et al., 1979). Although it is still debated whether this predictive context facilitation is due to an easier integration of the best-fitting candidate or the actual prediction, the existence of the facilitative effect has repeatedly been found for both monolingual and bilingual listeners (Batel, 2020). At the same time, bilingual speakers have shown to be slower than monolinguals in their processing (Shook et al., 2015, but see Bylund et al., 2022), and one of the possible reasons for that can be the lexical competition among similar items within the language of input and across other language(s) inside one brain. The size of the interlingual lexical competition effect does not simply depend on the number of competing candidates but is relative to the extent of their similarity, which may be extreme, e.g., in the case of cognates – words, overlapping in meaning and form (Sunderman & Schwartz, 2008).

2.2 Cognates

Since more similar words within or across languages co-activate each other more strongly, they create a bigger interference or priming effect (Lagrou et al., 2013b). Cognates are words which share cross-linguistic similarity up to the extreme degree of being (near) identical in their semantic and form representations. However, languages may bear certain unique phonological or orthographic features (e.g., the Swedish-specific letters *ä, å* and *ö* (/ɛ/, /o:/, and /ø/) and the sounds /ɕ/ in *kjol* [ˈɕuːl] (skirt) and /ɧ/ in *sjö* [ˈɧøː] (lake)), thus, the cross-linguistic similarity is not always complete, e.g., the Swedish-English cognates *bälte* [²bɛ̝lː.tɛ̝] ("²" stands for pitch accent 2) and *belt* [ˈbelt]. Consequently, it has been suggested (e.g., by Van Assche et al., 2011) that the cognate status should be regarded as a continuum rather than a discrete characteristic. To illustrate, it has been found that while the so-called 'identical cognates' (whose forms completely overlap across languages, e.g., *ring* in both Swedish and English) are immune to the sentence constraint effect, partial cognates, not sharing 'enough' form similarity, can be affected by sentence constraint (Duyck et al., 2007).

The cognate effect discussed by Van Assche et al. (2011) and many others is facilitative with the logic behind it being that because of the multiple-level overlap, several languages get co-activated at only one item presentation, which then facilitates (accelerates) recognition of the relevant word, resulting in shorter reaction times and higher accuracy. Consistent with Van Orden (1987), Van Assche et al. (2011) used an orthographic similarity score of at least 0.40, obtained from the NIM database (Guasch et al., 2013) (e.g., the Swedish *hjärta* and the English *heart* have the score of 0.48), and observed that the facilitation for such cognates remained robust even in the semantically constraining sentential context. Due to the findings that orthographic and phonological representations correlate (Shook & Marian, 2013; Thierry & Wu, 2007), it may be possible to apply the same 0.40 measure to analyse the processing of auditory cognates, albeit with caution and considering the above-mentioned language-specific letter-sound mapping. For instance, the Swedish-English cognates *bänk* [ˈbɛ̝ŋːk] and *bench* [ˈbɛntʃ] sound more similar than they are spelled, consequently, although having an orthographic similarity score of 0.35, they might be perceived in listening as near-identical cognates.

Numerous studies have explored different factors which can interact with the cognate facilitation effect, including the task, the stimulus list composition (i.e., whether a list contains identical or both identical and non-identical cognates), and the input language status (Lijewska, 2022; Lauro & Schwartz, 2017). For example, exploring the cognate effect as a function of language dominance, Blumenfeld & Marian (2007) observed the L2 English spoken word recognition by German-English and English-German bilinguals in the face of the phonological interlingual competition. The eye-tracking method was used with the visual world paradigm. The target word was either a cognate or a noncognate. The robust cognate effect was found for both groups but noncognate German interference was only observed when German was the participants' first and dominant language. However, in the study by Van Hell & Dijkstra (2002), the cognate effect from L1 Dutch–L3 French disappeared when participants' L3 proficiency was not high enough. Consequently, both language proficiency and the cognate status of the critical word have proven to be significant for the cross-linguistic competition to stay robust.

2.3 Models of bilingual language processing

Among the most prominent bilingual online language comprehension frameworks, to date, are the Bilingual Interactive Activation plus (BIA+) model (Dijkstra & Van Heuven, 2002) and the Bilingual Language Interaction Network for Comprehension of Speech (BLINCS) (Shook & Marian, 2013). Both computational models assume a single semantic store shared for linguistic representations across languages and posit spread activation of similar representations regardless of the language they 'belong to'. While BIA+ focuses on the written language and gives only general predictions for speech processing, BLINCS captures the details of sequentially unfolding auditory comprehension. Before describing both models, two earlier frameworks will be briefly considered and the description of monolingual speech perception models Cohort (Marslen-Wilson, 1984, 1987), TRACE (McClelland & Elman, 1986), and Shortlist (Norris, 1994) can be found in Appendix A.

2.3.1 BIMOLA and SOMBIP

The bilingual interactive model of lexical access (BIMOLA) (Grosjean, 1988) is based on TRACE (Marslen-Wilson, 1984, 1987; Marslen-Wilson & Welsh, 1978), the first computational monolingual spoken word recognition model. Both frameworks posit three representational levels: acoustic features, phonemes, and words, but BIMOLA captures their functioning in the bilingual context. According to the model, the phoneme and word level representations across two languages are independent but interconnected (Tokowicz, 2015). When acoustic input is received by a listener, the corresponding feature units get activated and trigger the activation of phoneme and word units, which then feed the information back to the phoneme level, inhibiting other irrelevant items within the level. Importantly, BIMOLA posits two separate lexicons for each language, so that items across languages do not excite or inhibit each other, i.e., in word recognition, only within language candidates are considered. Meanwhile, top-down processes guided by, e.g., the knowledge about interlocutors' linguistic repertoires or switching habits, can pre-activate the corresponding language. The assumption is reminiscent of Grosjean's (1985, 2001) Language Mode Hypothesis, in which bilinguals can keep both or one of their languages activated depending on the context of communication.

Unlike BIMOLA, the Self-Organising Model of Bilingual Processing (SOMBIP), developed by Li and Farkas (2002), assumes a single integrated lexicon for two languages, within which the items are distinguished by the phonotactic language-specific principles (the pattern of phoneme sequences typical of one language) of the input (Shook & Marian, 2013). For instance, in Swedish, word initial phonemes /l/ and /r/ can only be followed by a vowel (Sigurd, 1965: 41; Hultin, 2017), e.g., *låda* [²loːda] (drawer) and rock [ˈrɔkː]. In Russian, consonants are also allowed in such positions (although rarely): *рвать* [ˈrvatʲ] (to rip), *лгун* [ˈlgun] (lier). Consequently, hearing the initial /rv/ or /lg/ excludes Swedish items for Russian-Swedish learners. A similar categorisation is used by BLINCS while assuming a single lexicon is also characteristic of the BIA+ model.

2.3.2 BIA+ model

The Bilingual Interactive Activation plus (BIA+) model (Dijkstra and Van Heuven, 2002) is built upon the earlier Bilingual Interactive Activation (BIA) (Dijkstra & Van Heuven, 1998) and the monolingual Interactive Activation models (McClelland & Rumelhart, 1981). In addition to the orthographic level in BIA, BIA+ includes phonological and lexico-semantic levels, diminishes the role of the language membership nodes, and distinguishes between the influence of linguistic and non-linguistic context information. In the core of the BIA+ model lies parallel activation of items from both languages, guided by several levels of processing within the word identification subsystem (sub-lexical and lexical orthographic and phonological levels) and the top-down control from the task/decision subsystem (see Figure A1 in Appendix A). Moreover, the connections between the three word-identification levels are interactive and bi-directional, which is also typical of the further discussed BLINCS model.

According to the BIA+ model, lexical representations are stored in a shared integrated lexicon, and bottom-up processes make lexical access initially non-selective, so that input in one language triggers the activation of similar representations in both languages (Dijkstra & Van Heuven, 2002). For instance, for a Swedish-English bilingual, the cluster "*str*" in the Swedish word *strand* (beach) spreads the activation to the English *strong* and the Swedish *strut* (cone) at the orthographic and phonological levels, and to the semantically related *water, sun, baddräkt* (swimsuit), etc. The degree of co-activation is relative to the resting activation of each item, i.e., more frequently used items are activated faster and more strongly, which may depend on the language use, proficiency, and the item's similarity to the input. Consequently, more frequent items from a more dominant language can interfere more strongly than those from a weaker language, which has, indeed, been observed (Marian & Spivey, 2003). Moreover, items which are similar across several levels of representation (e.g., the English-Swedish cognates *cat* and *katt*), get co-activated more strongly, but differences in scripts (e.g., the Russian *кот* (cat)) can reduce the interlingual competition strength. Finally, feedback from each level of representation gradually inhibits irrelevant items, leaving one possible candidate.

Unlike BIA, BIA+ assigns less power to the language membership nodes (Dijkstra & Van Heuven, 2002: 187) making lexical features of words competing for selection more important than the language they belong to. However, the new role of the nodes is somewhat confusing: initially weak, they can, nevertheless, inhibit non-target language interference at later processing stages. To illustrate, if a sentence context is not biasing towards a particular candidate, the mere language of the input (i.e., the fact that the preceding words were in Swedish) cannot reduce co-activation of similar items in the other language. However, if there is enough semantic or syntactic information to limit the choice in favour of a certain word, cross-linguistic competition can be modulated or eliminated. Unfortunately, it is not clear how much biasing the context and/or how weak the non-target language interference must be.

While the first prediction regarding the low-constraint sentential context has been supported empirically (Lauro & Schwartz, 2017; Lagrou et al., 2013a, b), the situation with highly constraining or semantically rich sentences is more complex, especially with cognates. For example, Schwartz and Kroll (2006) found that the cognate facilitation effect (faster RTs when processing cognates than noncognates) was significantly reduced in highly constraining sentences, but Van Assche et al. (2011) observed it staying robust in both low- and high-constraint contexts. Moreover, Schwartz and Kroll (2006) argue that the BIA+ account of the high-constraint sentence effect (arising from enhanced semantic activation) cannot explain the modulation of the cognate effect they observed. Since cognates share semantics in both languages, the rich semantic context should not *discriminate between the languages* (Schwartz and Kroll, 2006: 209), unless the language nodes were preactivated by the context earlier (i.e., before the semantic level activation), which appears to contradict the weak role of the nodes in BIA+, especially at earlier processing stages.

Finally, the BIA+ word recognition system consists of a separate linguistic information unit and a task/decision system which is influenced by task demands and/or speaker's strategies or expectations from a non-linguistic context. The task system together with the word identification unit, can restrict the initially non-selective access at a later stage.

To conclude, the BIA+ model predicts that although the initial lexical access is non-selective, task demands and speaker's expectations together with the rich sentential context can affect the degree of interlingual co-activation at later processing stages. To what extent and depending on which factors exactly such modulation can happen remains unclear. This and some other limitations of the BIA+ model (e.g., it can only consider four-letter-long words) have been addressed in the Multilink model (Dijkstra et al., 2019) which combines the main assumptions of BIA+ and the Revised Hierarchical Model (Kroll & Stewart, 1994), capturing production and translation. To date, the model is limited to Dutch and English and is still being tested for various parameter settings, thus, it will not be discussed at this point.

2.3.3 BLINCS model

Although the BIA+ model can be generalised to speech processing because it considers phonological representations which have shown to relate to the orthographic form effects (Dijkstra & Van Heuven, 2002; Rastle, 2011), the model does not capture all the details of speech comprehension unlike the Bilingual Language Interaction Network for Comprehension of Speech (BLINCS) (Shook & Marian, 2013). Based on an interconnected network of four dynamic, self-organising maps of representation (phonological, phono-lexical, ortho-lexical, and semantic), the model excludes the need for a global language identification unit, provides a strong account of the cognate effect, and adds a layer of audio-visual information (see Figure A2 in Appendix A).

The BLINCS phonological level is based on PatPho (Li & MacWhinney 2002) and can capture different aspects of a phoneme, e.g., voicedness and the place of articulation. In the phono-lexical map, a phoneme three-element vector (each capturing a different aspect of this phoneme) is embedded into syllabic phrases, which helps to avoid a simple ordered structure problem, e.g., not recognising *tap* and *trap* as similar words because of /r/, breaking the order (Shook & Marian, 2013). The model also includes ortho-lexical and semantic levels. The semantic level is built upon the Hyperspace Analogue to Language (Burgess & Lund 1997, Lund & Burgess 1996) which can automatically derive the meanings of words based on their co-occurrence frequency information. Additionally, BLINCS includes the integration of audio-visual information which can be received from a visual scene (objects or images people see while listening) and a vocal apparatus (how phonemes are articulated by the lips and mouth). When the visual-input module detects objects within its scene, the resting activation of their semantic representations increases in both languages (Shook & Marian 2013: 5–6). For example, for an English-Swedish bilingual, seeing an apple triggers the pre-activation of its verbal labels *'apple'* and *‘äpple’* (in Swedish), which has been observed for other languages (Chabal & Marian, 2015; Van Holzen & Mani, 2014).

The information from the input is mapped onto a node which is constantly updated and self-corrected to modify the item’s location and distance from the nodes of other items as the speaker’s language proficiency increases. Similar to SOMBIP (Li and Farkas, 2002), BLINCS is based on the Hebbian learning principle “what fires together wires together” (Hebb, 1949), which means that if items get activated together, their interconnection becomes stronger, and they are placed closer to each other on the nodes. Consequently, co-occurring items get co-activated more strongly and faster than other items. Meanwhile, translation equivalents (e.g., *apple* and *яблоко* in English and Russian) are located within the same semantic node but on different lexical nodes because, unlike BIA+, BLINCS posits language-specific separated lexicons integrated into one system. That means that cross-linguistically similar words, e.g., cognates, are located next to each other on their form-representation nodes, but most other words in their closest proximity are in their original language (e.g., Swedish *äpple* has a majority of Swedish words below it while the English *apple* – English words). Separating the two language lexicons helps BLINCS to avoid the problem with the language nodes in BIA+ discussed above.

Another distinctive feature of the model is a 10%-rate gradual decay mechanism, which excludes items that no longer match the input but keeps the traces of the earlier received information. For instance, when processing the Swedish *hund* [ˈhɵnːd] (dog), the activation of the initial phoneme /h/ starts decaying at the presentation of /ɵ/, but when the following phoneme /n/ is processed, the previously activated /h/ is also considered to further select the intended word. Thus, the competition between phonologically overlapping items (e.g., the Russian word *художник* [xʊˈdoʐnʲɪk] competing with *hund* [ˈhɵnːd]) within and across languages disappears gradually.

In BLINCS, different representational levels are highly interactive, and information is spread bi-directionally inside one level of representation (e.g., within a phonological map) and across different levels, making the activation in one level the sum of the proportional activation from all the other levels. This can explain the robustness of the cognate effect: being similar across several levels of representation, they are processed faster and less costly than noncognates (Shook & Marian, 2013). Moreover, in the BLINCS mapping, cognates tend to be located close to the language-region borders, making them more immune to the linguistic context but allowing them to benefit from the double language activation (Shook & Marian 2013: 15).

Finally, the bi-directionally and laterally spread co-activation principle allows BLINCS to explain covert competition from items which do not directly match input in their form (Shook & Marian, 2019). There are two ways of co-activation: it can be triggered by the semantic level feedback (e.g., hearing “*duck”* activates the word *bird*), and the initial activation from the input can spread laterally at the lexicon level from the co-activation of translations, i.e., hearing "*duck"* activates the English orthographic and phonological forms and the Spanish translation *pato* (duck), which, in its turn, co-activates other Spanish and English cohorts, e.g., *pala* (shovel) (Shook & Marian, 2019).

2.3.4 Predictions of BIA+ and BLINCS

While BLINCS does not provide any strong predictions concerning the sentential context effect, it appears to agree with the BIA+ assumption that the low-constraint sentence context (providing only the language membership but not biasing towards any word) cannot modulate cross-linguistic competition (Shook & Marian, 2019). Considering high-constraint sentences, the two models' expectations may differ. While BIA+ clearly assumes that the target word-biasing semantics of a sentence can modulate non-target language interference, the BLINCS account can be more nuanced. As well as considering bi-directional *sequential* feedbacks within and across representational levels, BLINCS also assumes the direct influence of visual scene information; captures the effect of covert co-activation and posits gradual activation decay. Consequently, the context semantic constraint effect might modulate the competition effect relatively to the strength of the cross-linguistic competition. For instance, when hearing the Swedish "*trumma"* (drum) and seeing a picture of a *pipe* (*pipa* in Swedish and *трубка* [ˈtrupkə] in Russian), the initial phonological overlap between *trumma* and [ˈtrupkə], will co-activate the Swedish-English equivalents *pipa* and *pipe*, which, being cognates, may create a stronger cross-linguistic competition compared to the situation when the phonologically competing Russian equivalent *трость* [ˈtrostʲ] co-activates its Swedish-English noncognate translations *käpp* and *cane*. Such a 'double' competition effect is potentially possible in trilingual speech processing.

The current study aims to investigate how cross-linguistic competition of varying degrees and kinds (overt L1 Russian L3 Swedish phonological and covert L2 English L3 Swedish cognate interference) interacts with low- and high-constraint L3 Swedish auditory sentence context. In particular, it is questioned whether the resulting double cross-linguistic interference can become cumulative, staying robust even in semantically constraining sentences.

3. Literature review

In recent years, considerable work has been done exploring bilingual language processing, focusing on visual and spoken word recognition. In order to understand interactions across multiple lexical items, the degree and nature of their cross-linguistic similarity (e.g., a cohort or cognate status) and the context of their presentation (as single words or in sentences) have been manipulated. This has allowed to address one of the crucial questions in the field – whether multilinguals can switch off their irrelevant language(s) using the top-down mechanisms, operating on the basis of language or task contexts. Additionally, the influence of various factors (interlingual similarity degree, proficiency, etc.) has been explored.

3.1 Cross-linguistic co-activation in bilingual word recognition

Spivey & Marian (1999) were among the first to investigate bilingual lexical access selectivity in spoken word recognition and the effect of prior language context (e.g., the language of instructions). Late Russian learners of English living in the US were instructed in Russian or English to move objects in a display and their eye-movements were recorded. The critical nouns were interlingual cohorts. As a result, e.g., when hearing in Russian "Poloji *marku* nije krestika" (Put the stamp (*marku*) below the cross) and seeing a marker (*flomaster* in Russian), the participants had more gazes to the *marker* than filler objects. The competitor trials also yielded longer reaction times compared to the no-competitor trials (e.g., one including a ruler, *linejka* in Russian, as opposed to a *marker*). The results suggest that the bilinguals' English must have interfered with Russian. Additionally, the language of instructions affected the lexical interlingual competition asymmetrically – L2 English influenced the competition more than L1 Russian. This is surprising because, typically, the L1 interferes more strongly (Marian & Spivey, 2003). The researchers suggest that participants' immersion in the L2 English-speaking environment made their L2 more dominant, resulting in its greater interference. To conclude, the findings show that top-down information (e.g., the language of instructions) cannot eliminate the influence of bottom-up visual and auditory information, but their interaction can be modulated by the preceding linguistic context, which may be affected by language dominance.

The robustness of the interlingual phonological overlap effect has been repeatedly demonstrated for other language combinations and exploring various factors, e.g., cross-lingual similarity, non-verbal information, and the cognate effect (McDonald & Kaushanskaya, 2020; Chabal & Marian, 2015; Blumenfeld & Marian, 2007; Weber & Cutler, 2004, to name a few).

While the above described interlingual cohort effect was form-dependent (the target and the competitor's translation shared their phonological onsets), in a 2019 study, Shook & Marian explored whether a similar effect occurs if the interlingual activation happens covertly, i.e., without any overt overlap with the input information. 15 English-Spanish bilinguals and 15 English monolinguals performed a picture-word recognition task while listening to English or Spanish words, and their reaction times, eye-fixations, and accuracy were measured.

The results showed that the bilinguals looked at the covert competitors more than the fillers in both languages to a similar extent, while the monolinguals did not show any differences between competitors and fillers. For instance, seeing a display of four pictures with two distractors and the pictures of a *duck (pato* in Spanish) and a *shovel (pala* in

Spanish*)* and then hearing *duck*, the bilinguals looked at the *shovel* more than at the distractors, which suggests that the English *duck* co-activated its Spanish equivalent *pato*, which then triggered the activation of the phonologically overlapping *pala* in Spanish. Thus, in the absence of an overt form-overlap, a single language could activate the words' translation equivalents which then spread the activation to phonologically similar unheard candidates. This overt-covert cascaded activation is in line with the BLINCS model. Notwithstanding the important findings, the study has at least two limitations: a small number of participants and the potential language-per-block presentation priming of the corresponding language (Shook & Marian, 2019).

3.2 Sentence-level bilingual processing

In their seminal study, Chambers and Cooke (2009) focused on the interlingual phonological competition in spoken sentences and the L2 speakers' proficiency effect. 20 English dominant French bilinguals were recruited to perform a word recognition task while their eye-movements were monitored. The participants saw a display with four pictures and 2,000ms later, heard a sentence which was either nonrestrictive (example (1)) or competitor incompatible (example (2)). In the critical trials, the four objects on the display represented a target (e.g., *la poule* /pul/ (the chicken)), its French-English homophone competitor (*the pool* /puːl/, which is *la piscine* in French), a semantically related competitor-prime object (a *towel* for the competitor *pool*) in half of the trials and a filler. The semantic competitor-prime was introduced to test whether its presence would increase the interlingual competition effect.

(1) Marie va décrire la poule

Marie go-PRS-3SG describe-INF art.F.DEF. chicken

Maria will describe the chicken

(2) Marie va nourrir la poule

Marie go-PRS-3SG feed-INF art-F.DEF. chicken

Marie will feed the chicken

As a result, the participants showed more fixations on the interlingual competitors in the nonrestrictive sentence context (1) but significantly reduced competitor-fixations in the competitor-incompatible sentences (2), meaning that the semantic sentence constraint modulated the extent of the interlingual competition. Meanwhile, the proficiency levels did not correlate with the performance, neither did the competitor-priming have any effect. The findings are in line with the BIA+ model, which assumes that a constraining sentence context can modulate cross-linguistic competition independently of L2 proficiency (Schwartz and Kroll, 2006).

The study has several limitations, however. Firstly, the competitor-target grammatical-gender congruency was counterbalanced (half of the targets and competitors belonged to the other gender group, requiring a different preceding gender-marked article in French), which is concerning because L2 learners may be able to predictively use gender cues before nouns (Hopp, 2013; 2016) and, thus, competitor-gender incongruency could have compromised the interlingual homophone effect, especially, in restrictive sentences biasing towards the target more. Additionally, the participants' proficiency was self-rated, which may be problematic, considering that the research particularly addressed the proficiency factor.

The results of Chambers and Cooke (2009) diverge from the findings of Van Assche, Drieghe, Duyck, Welvaert, & Hartsuiker (2011) who explored the interaction between sentence constraint (low vs. high) and cross-linguistic co-activation in cognates in an eye-tracking study using a visual word recognition task. The participants were 29 late Dutch learners of English. The study tested the prediction of the BIA+ model that the mere linguistic context of a sentence is not enough to significantly modulate cross-linguistic co-activation, but the semantic constraint, on the contrary, should be able to do so, possibly, at later processing stages, when top-down information can prevail over the bottom-up induced parallel language activation. Additionally, the research explored whether the cognate facilitation effect is a function of cognates' qualitative or quantitative difference from other lexical items. Mostly non-identical cognates were used, and the degree of their cognateness was assessed using the cross-linguistic orthographic similarity score (Guasch et al., 2013). The study was later replicated by Kurnik (2016) for Swedish-English learners.

Two main experiments were conducted with 29 bilinguals: 1) a word-level lexical decision task and 2) reading high (example (3)) and low (example (4)) constraint sentences, and experiment three repeated the second task with an English native control group (24 participants).

(3) Salsa has become a popular *dance* in Belgium (*dans* in Dutch).

(4) Ann has seen a popular *dance* in Belgium.

The cognate facilitation effect (faster reading times and more word skipping for cognate than noncognate words) was found in both experiments regardless of sentence constraint or processing stage (because the effect was also observed in the late reading time measure *go-past time*, which it believed to reflect the word semantic integration (Van Assche et al., 2011: 96)). Moreover, the effect of the interaction between the processing measures and the cognate effect was relative to the degree of the Dutch-English words' interlingual similarity. Thus, the findings support the assumption that the bilingual linguistic system is largely non-selective at either processing stage. The study also demonstrates the continuous nature of cognates, making them quantitatively but not qualitatively different from other lexical items. Consequently, Van Assche et al. (2011) argue against the prediction of BIA+ that a semantic constraint of a sentence can restrict linguistic access selectivity. It is important to note, however, that the sentences used by Van Assche et al. (2011) and Kurnik (2016) were of varying lengths allowing for a different number of items between the critical words and semantically biasing item(s), which might potentially influence word recognition (Dijkgraaf et al., 2019).

Similar to Van Assche et al. (2011), Lagrou, Hartsuiker, & Duyck (2013a) found that even a highly-constraining sentence context could not significantly modulate the interlingual competition in an auditory lexical decision task when the critical words were interlingual homophones (e.g., the Dutch *lief* /li:f/ (sweet) and the English *leaf* /li:f/). The study explored whether lexical access non-selectivity in a sentence can be influenced by 1) an L2 sentence context; 2) semantic constraint; and 3) the speaker's native language (accent), which can provide sub-phonemic cues to listeners. 64 Dutch-English late bilinguals listened to high- and low-constraint sentences in their L2 English, pronounced by either English(L1)–Dutch or Dutch(L1)–English speakers and then decided whether the final item was a real word or not.

The participants had longer reaction times in the homophone-containing trials than in the controls and the semantic constraint effect (yielding shorter reaction times) was also significant. Moreover, the participants processed the native English speaker trials faster than the Dutch-native ones. Crucially, though, the homophone effect remained significant, albeit smaller, in both high-constraint and Dutch-speaker conditions. This suggests that although the biasing sentence context and the sub-phonemic cues could reduce the interlingual homophone effect, they did not eliminate it, which is more consistent with the results of Van Assche et al. (2011) than the findings of Chambers and Cooke (2009).

Finally, the divergence between the three studies may be explained by the different methods (tasks, sample sizes) but it can also be due to the critical words' interlingual similarity. Lagrou et al. (2013a) used a bigger number of full homophones than Chambers and Cooke (2009) and Van Assche et al. (2011) explored the effect of cognates. Crucially, Dutch and English (in the 2011 and 2013a studies) are cross-linguistically more similar than French and English, which could have made the Dutch-English co-activation stronger, yielding a more robust cross-linguistic co-activation effect.

The observed cross-linguistic competition may at least partially be responsible for delays in bilingual processing compared to monolingual comprehension (Dijkgraaf et al., 2019), which, on the other hand, can be related to the bilinguals' weaker lexical access. These assumptions were investigated by Shook, Goldrick, Engstler, & Marian (2015), who recruited 30 sequential bilinguals (15 English and 15 German-native speakers) and 15 English monolinguals to do an eye-tracking picture-word recognition task while listening to low- and high-constraint sentences in English. The display contained four pictures, which, in the critical trials, were unrelated fillers and a target (e.g., showing *pills*), phonologically competing with another picture's German translation (e.g., *Pilz* in German meaning *mushroom* in English). Importantly, the pictures appeared only 200ms before the target noun onset.

As expected, the cross-linguistic competition effect was not significant, because the time-window between the picture presentation and the target onset was too short for the non-target language interference to gain enough strength (Huettig & McQueen, 2007). But even when the interference was absent, only the L2 English-listening L1-German participants used the target-constraining sentence cues similarly, albeit more slowly and weakly as evidenced by their gaze-fixations than the monolingual control group. The L1-English bilinguals did not rely on the constraint to a visible degree. The pattern of results is in line with some earlier studies (e.g., Titone et al., 2011; Libben & Titone, 2009) but appears to contradict the findings that bilinguals use contextual cues less efficiently in their L2 than L1 (Dijkgraaf et al., 2019) or that they can use the cues to a comparable degree in both languages (Dijkgraaf et al., 2017; Batel, 2020). This divergence across the studies may be explained by a different complexity of stimuli sentences (Chun & Kaan, 2019), number of participants and diverging picture-display presentation times providing different time-windows for lexical access.

Crucially, however, there is agreement that differences in how mono- and bi-lingual, L1 or L2 listeners use predictive sentence cues may arise from cross-linguistic interference, at least to some extent (Chun & Kaan, 2019; Hopp, 2016), and/or from weaker lexical connections in later acquired, less proficient language(s), resulting in less effective spread of activation (Shook et al., 2015; Dijkgraaf et al., 2017, 2019). But the similarity of the processing patterns across the groups suggests rather quantitative than qualitative differences. The question we address in the present study is whether adding another language might change the interaction between a sentence context and cross-linguistic interference (caused by lexical competition)?

3.3 Trilingual processing

Most studies on trilingual speakers are concerned with the process of acquiring the third language, L1 or L2 transfer, and cross-linguistic similarity effects (Szubko-Sitarek, 2015). The scope of the research covering word recognition, especially in spoken sentences, remains scarce. At the same time, one of the benefits of studying trilingual language processing is the advantage of using one multi-factorial experimental set-up with the same population. Importantly, while those few studies looking at L3-processing have shown that, largely, the findings on bilingual speakers can be generalised to trilinguals (Blank & Llama, 2019), others have found certain discrepancies, the nature of which calls for more investigation (Lijewska, 2022).

In a seminal study, Lemhöfer, Dijkstra, & Michel (2004) examined lexical access selectivity and linguistic context effects in trilinguals, investigating whether the cognate facilitative effect can be cumulative across one speaker's multiple languages. Dutch-English-German trilinguals performed a reading lexical decision task in three conditions: 1) L3 German-only words (controls), e.g., *Sache* (*thing* or *zaak* in Dutch), 2) L1 Dutch-L3 German cognates, e.g., *macht* (*power*), and 3) 'triple' cognates in the three languages, e.g., *plan*. Before the experiment, the participants had read texts in Dutch or English, creating a linguistic context (only German was used for the main experiment). While both cognate conditions yielded faster reaction times than controls, crucially, the triple cognate effect was bigger than the double one, independent of the previous language context. The results suggest that the non-target language co-activation stayed robust regardless of the preceding linguistic context and could be cumulative.

Continuing to test the assumption of the BIA+ model regarding nonselective bilingual lexical access (extended to multilinguals) and a special character of cognates, Szubko-Sitarek (2011) replicated the findings by Lemhöfer et al. (2004), showing the cumulative cognate facilitation effect in a similar lexical decision task performed by Polish-English-German trilinguals but only in the experiment when the target language was the participants' weakest L3 German.

In the second experiment, which explored whether the L2 could affect L1 processing in trilinguals, 19 participants processed their L1 with either triple (Polish-English-German), double cognates (Polish-German) or Polish-only controls. The results showed a strong cognate facilitation effect (shorter RTs and fewer errors), but no significant difference between triple and double cognate conditions, suggesting that there was no visible effect of L2. Similar results were earlier obtained by Van Hell & Dijkstra (2002) who tested Dutch-English-French trilinguals in a lexical-decision task and found that only proficient French (L3) speakers experienced the cognate facilitation effect in Dutch-French cognates while the Dutch-English (English as an L2) cognate facilitation effect stayed robust regardless of proficiency levels. The researchers from both studies conclude that for a weaker language to affect L1 comprehension, the language should reach a certain level of proficiency.

Overall, the above-mentioned studies have demonstrated the parallel activation of all the three languages in both L1 and L3 processing, but the strength of their co-activation could depend on participants' proficiency in their non-native language(s) and the task demands, which is consistent with the BIA+ model. Additionally, the pattern of results across the studies supports the idea of *the combined cross-linguistic influence* (De Angelis, 2007; Ringbom, 2007), which assumes that increasing the number of languages in one mental lexicon results in a bigger cross-linguistic influence, experienced by the target language (Szubko-Sitarek, 2011: 205).

A different approach has been taken by Bartolotti & Marian (2018), who asked their Spanish-English bilinguals to learn the artificial L3 Colbertian, whose words conflicted with the two natural languages in their letter-sound mappings. For example, the Colbertian letter *N* corresponded to the phoneme /*f*/, differing from both Spanish and English. Similar to Szubko-Sitarek (2011) and Lemhöfer et al. (2004), Bartolotti & Marian (2018) used the cognate effect as a reliable indicator of cross-linguistic influence. The newly learnt L3 words, created on the base of Spanish-English (non)cognates, could overlap orthographically, but not phonologically with either Spanish or English.

One of the five tasks used in the study was exploring cross-linguistic competition through spoken word recognition in a visual world search. In the critical trials, the display showed an L3 Colbertian target (e.g., *nake* /fuwɔ/) and an interlingual competitor, which overlapped in its orthographic form either with English-only (e.g., *cake/torta*) or, being a cognate, with English and Spanish (e.g., *rose/rosa* competing with the target *roke* /hiwɔ/).

The results of the task showed that L3 auditory input, containing a word which orthographically overlapped with the non-target English form spread the activation to this English word, evidenced by more fixations on the competitor compared to other objects in the display. Moreover, cross-linguistic competition was greater for the words that overlapped with two languages compared to one, revealing a cumulative effect. However, the effect decreased with more training, making the results only partially compatible with Lemhöfer et al. (2004) and Szubko-Sitarek (2011), who observed the increased cumulative effect with a higher L3/L2 proficiency but only in L1-processing. Bartolotti & Marian (2018) also found that L1, but not L2, interlingual similarity created more interference in L3 processing, but again, the difference decreased with more training in the new language, while the overall competition remained.

Consequently, the findings suggest that the activation in a trilingual language system goes in a multi-step cascaded way, where the target L3 phonological level co-activates the same language orthographic representations, which, in its turn, triggers orthographic neighbours in L1 and L2, spreading the activation to the corresponding lexical items, which then compete with the L3 word for selection. The cascaded activation in trilinguals is consistent with findings for bilinguals (Shook & Marian, 2019) and the assumptions of the BLINCS model (Shook & Marian, 2013). However, with the high regard for the above research, acquiring an artificial language in a laboratory is different from learning and using a natural language in its speaking community. It is, thus, important to explore, how three *natural* languages interact and how the sentence context affects this interaction, e.g., if the observed cascading activation creates a cumulative effect so strong as to, possibly, stay immune to the otherwise robust constraining sentence effect.

In the study by Szubko-Sitarek (2011), the researcher mentioned a similar limitation regarding the nature of a lexical decision task, looking at only single-word processing. To address this limitation, a recent study by Lijewska (2022) combined the approaches used by Van Assche et al. (2011) and Lemhöfer et al. (2004) to explore the interaction of the previously observed triple cognate facilitation effect with sentential semantic bias. The study used an eye-tracking method and a visual word recognition task in English, performed by 36 Polish-English-German trilinguals (the English and German status was mixed). Two factors were manipulated: the cognate status – triple non-identical cognates, e.g., *diament–Diamant–diamond* in Polish, German, and English, respectively, versus English-only controls, e.g., *kurczak–Hähnchen–chicken* and the sentence type: low- versus high-constraint context.

Contrary to the prediction that there would be robust triple cognate facilitation effects in both sentence types, the participants had longer gaze durations only on the control items but not for cognates in the low-context sentences compared to the high-context conditions, showing no cognate facilitation effect in either context. The controls were also affected by the semantic bias earlier than cognates, which contradicts even those studies in which the cognate effect disappeared in the later processing time (Libben & Titone, 2009).

Thus, the findings are inconsistent with the previous results for bilinguals (Van Assche et al., 2011; Kurnik, 2016; Dijkstra et al., 2015), but the possible explanations for this are plentiful. On the one hand, it may be concluded that trilingual non-native language processing is fundamentally different from bilingual comprehension, on the other, the difference might as well be quantitative, arising from a bigger number of conflicting candidates and even more complex interactions among various factors at play. Additionally, Lijewska (2022) underlines methodological differences across the studies: different sentence lengths, critical items (whose cross-linguistic similarity was assessed using different methods, e.g., Lijewska (2022) relied on subjective assessment as opposed to an orthographic similarity score used by Van Assche et al. (2011)). The participants' profiles also differed. Lijewska (2022) additionally hypothesizes that the cognate facilitation effect may be task-specific (half of the 2022 stimuli yielded a strong cognate facilitation effect in a production study by Lijewska & Chmiel (2015)), and it is possible that the effect of only one of the two non-target languages may be significant (Van Hell & Dijkstra, 2002; Szubko-Sitarek, 2011). This could be the first language as the most used, best-known, and earliest acquired, or a more typologically similar or dominant language. Finally, the effect could depend on the cross-linguistic (dis)similarity across the critical languages (Alemán Bañón & Martin, 2021; Westergaard et al., 2017).

Taken together, the ample research on bilingual processing and the scarce findings on trilinguals suggest lexical access non-selectivity in the single word and low-constraint sentence contexts but a potentially more nuanced interaction between highly constraining sentences and cross-linguistic interference of a varying degree. Specifically, in bilingual word recognition, it has shown to depend on the extent of interlingual similarity (Van Assche et al., 2011). The only recent study on trilingual word recognition in high- and low-constraint sentence contexts has obtained results which are inconsistent with the findings on bilingual speakers, but numerous possible explanations of these discrepancies require further investigation.

4. The current study

The current study examines sentence comprehension in Swedish among L1 Russian L2 English L3 Swedish learners (with a late age of L3 acquisition). The study explores whether, in the course of online comprehension, there is cross-linguistic competition from one or two non-target languages, and whether the competition is modulated by whether the carrier sentence is semantically low or highly constraining with respect to the upcoming noun. The main task consists of a lexical selection task with sentences presented in the auditory modality. Three main research questions (RQ) are addressed:

RQ 1. Does participants' L1 Russian get activated during an auditory lexical selection task in their L3 Swedish?

RQ 2. Does participants' L2 English get activated during an auditory lexical selection task in their L3 Swedish and does it modulate the potential L1 Russian activation?

RQ 3. To what extent does top-down information (i.e., sentence constraint) modulate the potential cross-linguistic competition from L1 Russian and/or L2 English with L3 Swedish?

The three languages make an interesting combination because, being typologically similar, English and Swedish share many lexical and syntactic features. In addition, although Russian uses a different script, it has several phonemes similar to those found in the Swedish phoneme inventory. For instance, /ɕ/ (which English lacks) and /ø̞/ in *kött* [ˈɕø̞tː] (meat) resemble the Russian /ɕ/ and /ɵ/ in *щётка* [ˈɕːɵtkə] (brush). This allows for testing phonological competition from Russian while listening to Swedish.

The visual world paradigm is used for an auditory lexical selection task consisting of L3 Swedish auditory sentences and a display of two pictures. Using a within-subjects design, the participants' reaction times and accuracy are compared across conditions, as a function of three factors: 1) phonological overlap between an L3 Swedish target and a competitor's L1 Russian translation, e.g., *mål* [ˈmoːl] (goal) overlapping with *молния* [ˈmołnʲɪjə] (lightning); 2) a competitor's L2 English L3 Swedish cognate status, e.g., *hammer* and Swedish *hammare*; and 3) semantic constraint of the carrier sentence. For example, the verb in the high-constraint sentence (5) biases a listener towards the Swedish word for "goal" (*mål*) but not towards the Swedish word for "lightning" (*blixt*) or "hammer" (*hammare*). In contrast, the verb in the low-constraint sentence (6) does not.

(5) Han har stått i *målet* / blixt /hammare

he.3SG. have-PRS. stand-PTCP in goal-DEF.SG.N./lightning-SG.C./hammer-SG.C.

He has stood in the goal / lightning / hammer.

(6) Han har sett *målet* / blixten / hammare

he.3SG. have-PRS. see-PTCP goal-DEF.SG.N./lightning-SG.C./hammer-SG.C.

He has seen the goal / lightning / hammer.

4.1 Research questions and predictions

1. Does participants' L1 Russian get activated during an auditory lexical selection task in their L3 Swedish?

If so, the RTs in the trials where an L3 Swedish target noun phonologically overlaps with a competitor's Russian translation will be longer compared to trials where no overlap occurs. In general, this pattern is predicted by both BIA+ and BLINCS because the models posit that lexical access is initially non-selective, thus, allowing for bottom-up co-activation of a non-target language due to the similarity with the input.

2. Does participants' L2 English get activated during an auditory lexical selection task in their L3 Swedish and does it modulate the potential L1 Russian activation?

If so, the RTs in the tasks where a competitor is an English-Swedish cognate will be longer than noncognate competitor trials. Moreover, in the case of modulation, L1 Russian L3 Swedish target-competitor phonological overlap trials with L2 English L3 Swedish cognate competitors will be responded to more slowly than those where overlapping competitors are noncognates. Both models predict that cross-linguistically highly similar cognates get activated more strongly than noncognates. Although the cognate effect in the discussed literature was facilitative, it is predicted that its influence in this study will be impeding (resulting in longer RTs) because the cognates are competitors but not targets like in the studies discussed. BLINCS would be more suited than BIA+ to account for the potential cognate effect because the initial source of the effect would either be from the visual scene information (participants will only see a competitor) or from the covert L2 activation triggered by an L1 Russian competitor's translation phonological overlap with an L3 Swedish target.

3. To what extent does top-down information (i.e., sentence constraint) modulate the potential cross-linguistic competition from L1 Russian and/or L2 English with L3 Swedish?

Both BIA+ and BLINCS would predict that in semantically low-constraint sentences, bottom-up driven cross-linguistic competition will not be significantly affected by the mere linguistic context of a sentence (the Swedish language), meaning that in the low-constraint sentences, the conditions with both single (cognate or overlap) and double (cognate and overlap) cross-linguistic interference will be responded to more slowly than no competition (i.e., no interference) conditions.

If the high-constraint sentence context can modulate or eliminate bottom-up driven non-target language competition from an L1 Russian L3 Swedish target-competitor phonological overlap and/or an L2 English L3 Swedish cognate competitor, high-constraint sentences will elicit shorter RTs across the board with no difference between the high-constraint sentences with and without interlingual competition. Alternatively, if top-down information (i.e., sentence constraint) can modulate interlingual competition from only one of the non-target languages (overlap or cognate interference), but not from double interference competition (both overlap and cognate factors), then, in high-constraint sentences, the RTs will be longer in the double cross-linguistic interference trials (from both Russian and Swedish) than in the single interference (from Russian or English) or no competition (i.e., no interference) trials. There will be no significant difference between the RTs in the high-constraint sentences with single or no cross-linguistic interference. In a more nuanced way, if single cross-linguistic interference (from L1 Russian phonological overlap competition or L2 English cognate interference) stays immune to top-down information, there will be longer RTs in cognate competitor or target-competitor overlap trials than in no cognate or no overlap conditions in high-constraint sentences. It is predicted that L1 Russian L3 Swedish phonological overlap competition will be stronger than L2 English L3 Swedish cognate interference because Russian is the participants' first, earliest acquired language.

Finally, it is predicted that participants' individual characteristics can influence the effects. Longer Russian and English exposure may result in longer RTs overall, but more extensive use of and higher proficiency in Swedish might make the processing faster. The same pattern of results for the error rates is predicted for all the three questions. Such findings will suggest that trilingual speakers can use semantically constraining sentence contexts to facilitate L3 speech processing even when experiencing cross-linguistic interference, but the effect size of this interference is relative to the degree of cross-linguistic competition and the listener's language status (L1 or L2). Stronger L1 or double L1 and L2 interference can stay robust even in semantically constraining L3 sentences. The prediction that high-constraint sentence contexts cannot modulate or eliminate single or double bottom-up driven cross-linguistic interference, can be explained by BLINCS but not BIA+. BLINCS captures both overt (input-based) and covert (cascaded translation activation) cross-linguistic co-activation and includes the visual scene information influence on linguistic processing. It also assumes that the cognate effect may stay robust in any sentence context (Shook & Marian, 2013: 15) while the BIA+ account of the cognate effect in semantically rich sentences is confusing (Schwartz and Kroll, 2006).

5. Method

5.1 Participants

Forty-four adult L1 Russian L2 English late learners of Swedish were recruited for the study. The data of four participants have been excluded from the final analysis: one participant acquired English much later than Swedish. Another subject had lived in Sweden for less than a year. Data from one participant was lost due to a technical error in Pavlovia. Finally, one participant showed below 50% accuracy in the comprehension questions used to monitor participants' attention. The age of the remaining 40 participants (37 females) ranged from 22 to 60 (*M* = 36.4, *SD* = 9.3). The language background information was obtained using the Russian version of The Language Experience and Proficiency Questionnaire (LEAP-Q) (Marian, Blumenfeld & Kaushanskaya, 2007). All the three languages were asked about.

The participants were born in a Russian-speaking country and had Russian as their first (or one of the first) language(s). Most participants reported knowing other languages, which were either unrelated to the targeted linguistic combination or were of lower current use and/or proficiency. Additionally, 8 participants (20%) were balanced or sequential bilinguals in Russian and Ukrainian or Belarusian and one participant reported being a sequential bilingual in Russian and Icelandic (see Appendix B for details).

All participants acquired English before Swedish except for one subject who started learning Swedish and English at the ages of 8 and 9 (but almost simultaneously). Most participants acquired Swedish upon their arrival in Sweden within language courses and as a result of immersion, between the ages of 12 and 42 (*M* = 25, *SD* = 7.6). English was largely acquired earlier in a classroom environment in a Russian-speaking country (*M* = 7.7, *SD* = 3.4, range = 3 – 19).

Mean length of residence (LOR) in Sweden was 8.6 years (*SD* = 7.6, range = 1–30), and mean LOR in a Russian-speaking country was 26.6 years (*SD* = 8.7, range = 8–50). The English LOR was harder to determine because almost half of the participants considered Sweden an English-speaking country. Regarding the duration of stay in an officially English-speaking country, the LOR was 0.3 years (*SD* = 0.8, range = 0–5). All the participants reported using the three languages daily, but the individual amount of use of each language varied (see Appendix B for details).

Proficiency in English and Swedish was assessed using the English LexTALE (Lemhöfer & Broersma, 2012) and a non-standardized version of the LexTALE for Swedish (Borg, 2021). The mean scores (76.8 for Swedish and 74.1 for English) showed that the participants were, on average, very advanced. Seven and five participants scored ≥ 90 for Swedish and English, respectively.

5.2 Materials

5.2.1 Properties of the word stimuli

Most word stimuli were selected from the Swedish Kelly list (Kilgarriff et al., 2014) and online Russian word dictionaries. All word stimuli were concrete nouns. The Zipf value, which is a standardised measure of word frequency based on the corresponding language corpora (Van Heuven, Mandera, Keuleers, & Brysbaert, 2014), was used to control for the mean frequency of the nouns. The mean Zipf value across the three groups of nouns was 3.86 (*SD* = .67, range = 2.05–6.35). The noun stimuli properties, obtained from the AFC list (Witte et al., 2021; Witte & Köbler, 2019), can be found in Appendix C.

In order to determine if the noun properties were similar across the three sets of stimuli (target nouns, cognate and noncognate competitors), six ANOVA tests were run. The three sets were matched for frequency: $F(4, 235 = 1.24, p = 0.30)$; the number of letters: $F(4, 235 = .88, p = .48)$; syllables: $F(4, 235) = .88, p = .48$; phones: $F(4, 235) = 1.95, p = .10$; orthographic neighbours: $F(4, 235) = 1.51, p = .20$ and phonetic neighbours: $F(4, 235) = 2.12, p = .08$[2].

Similar to previous studies (Chabal & Marian, 2015; Shook & Marian, 2019), some word stimuli were compound nouns, which should not be problematic because only the initial overlapping phonemes are considered in this study. Additionally, several of the nouns were used in the plural because this form is more frequent for such nouns (similar to Shook et al., 2015). For instance: *leksaker* (toys), *pengar* (money), *hörlurar* (earphones). Several nouns were used in the plural to avoid the unstressed Russian vowel reduction discussed in the following section.

Initially chosen 1,600 nouns were then translated into Russian and English and the NIM database (Guasch et al., 2013) was further used to obtain the quantitative similarity score between the words. Recall that words with an orthographic similarity score (OS) ≥ 0.40 are typically considered cognates (Van Assche et al., 2011; Borg, 2021). A similar approach was adopted for the current study but with certain restrictions. Since the orthographic representation similarity depends on the scripts, the Swedish-specific letters which represent phonemes that are similar to those in English could be problematic to consider correctly based on the OS purely, especially for the spoken language similarity. To illustrate, the words *bänk* and *bench* are cognates in the CogNet v2 database, which considers the word origin and form (Batsuren, Bella, & Giunchiglia, 2019; 2022), but

[2] The phonetic neighbours' count showed a marginally significant difference, but since participants heard all the nouns inflected, the items' form properties would change. Another set of analyses showed that when inflected, the three groups were also compatible in their frequency: $F(4, 235 = 1.67, p = .16)$; number of letters: $F(4, 235 = .827, p = .51)$; syllables: $F(4, 235) = .88, p = .48$; phones: $F(4, 235) = 1.67, p = .16$ and orthographic and phonetic neighbourhood density: $F(4, 235) = 1.15, p = .33$ and $F(4, 235) = .981, p = .42$, respectively.

their OS is 0.35. Since this study is concerned with speech comprehension rather than reading, such and similar words were considered as cognates because they are close in their phonological representation ([ˈbɛ̞ŋːk] and [ˈbɛntʃ]). The other similar cases were, for instance, *häst* [ˈhɛ̞sːt] and *horse* [ˈhɔːs] (OS of 0.35); *päron* [ˈpæː.rɔn] and *pear* [ˈpɛə] (OS of 0.36), and *såg* [ˈsoːg] and *saw* [ˈsɔː] (OS of 0.38). The words *badkar* and *bathtub* (OS of 0.38) were also treated as cognates due to the limited number of available items and the high similarity of their phonological and orthographic representations: [²bɑːdkˌɑːr] and [ˈbɑːθtʌb], respectively. Conversely, *waitress* and *servitris* have the orthographic similarity score of 0.46 but highly diverging phonological forms: [ˈweɪ.trəs] and [sɛ̞r.vɪ.ˈtriːs]. They were not found to be etymologically related according to the CogNet v2 database, and were, consequently, treated as noncognates.

5.2.1.1 Target nouns

Forty-eight nouns were chosen as targets. The initial phoneme of each Swedish noun could not be shared with its English and Russian translations, e.g., *kudde* was excluded because its initial phoneme in English and Russian is /p/ (*pillow* and *подушка*, [pɐˈdu̧kə]). Although weak, such overlap might make the co-activation of a word stronger. The example of a selected target noun is "*bord* [ˈbuːɖ]–*table* [ˈteɪ.bᵊl]–*стол* [ˈstoɫ]*"* in Swedish, English and Russian, respectively. The targets were noncognates across the three languages based on the OS value and phonological representations.

5.2.1.2 Competitor nouns

The competitor nouns were either cognates or noncognates across the three languages. In order to form four conditions, 192 words were chosen as competitors (96 cognates and 96 noncognates) altogether resulting in 240 stimuli words: 48 targets + 96 cognates + 96 noncognates. None of the target nouns' translation equivalents across the three languages phonologically overlapped with the competitor's translations unless the competitor's onset was purposefully chosen to be shared with the target in its Russian translation or was an L2-L3 cognate, e.g., a selected overlapping set was "*bord* [ˈbuːɖ]–*table* [ˈteɪ.bᵊl]–*стол* [ˈstoɫ]" vs. "*papper* [²papːɛ̞r]–*paper* [ˈpeɪ.pəʳ]–*бумага* [buˈmaga]".

5.2.2 Phonological overlap

The amount of phonological overlap was determined by calculating the number of overlapping phonemes between the onsets of Swedish targes and competitors' Russian translations (based on IPA transcriptions). In addition, the orthographic forms of the Russian nouns were also taken in account. This was done because Russian unstressed vowels get reduced (Yanushevskaya & Bunčić, 2015). For example, while the first stressed vowel in [ˈgolɐvɨ] (heads) is /o/, the shifted stressed in the singular form necessitates the vowel reduction: [gəlɐˈva] but the orthographic form of the noun remains the same '*г**о**ловы*' (PL.) – '*г**о**лова*' (SG.). In what way this shift will influence the cross-linguistic phonological interference is not quite clear and may be an interesting matter to investigate in the future. Due to the limited number of criteria-matching words, in this study, the phonetic presentation was adopted as the initial and strongest factor, driving the cross-linguistic interference in spoken word recognition, but the orthographic overlap was also considered because it has shown to interact with the phonological form effect (Shook & Marian, 2013).

Consequently, the amount of overlap between a Swedish vowel and a similar reduced Russian vowel received a score of 0.5, e.g., the Swedish target *pengar* [ˈpɛ̝ŋːar] (money) and the competitor's *tupp* (cock) Russian translation *петух* [pʲɪˈtux] were considered to overlap by 1.5 phonemes. Additionally, where the plural noun form would shift the stress to the vowel in question, resulting in a larger phonological overlap, the noun was used in the plural (e.g., for the target *golv* [ˈɡɔlːv] (floor), instead of using the noun *гора* [ɡɐˈra] (a single mountain), the form of [ˈɡorɨ] (mountains) was elicited). This has resulted in the target-competitor phonological overlap being on average 2.18 initial phonemes for the noncognate competitors and 2.21 for the cognate competitors (from 1 to 4 phonemes in both groups).

5.2.3 Grammatical gender congruency

Both Russian and Swedish have grammatical gender, meaning that every noun belongs to a certain gender class (Corbett, 1991). In Standard Swedish, there are *common* and *neuter* gender classes (Borg, 2021: 4). Out of 240 nouns used in the study, 175 had common and 65 neuter gender but the gender distribution across the groups was matched ($F(4, 235) = .259$, $p = .904$). Since the criteria for creating the critical word sets were rigid, it would have been difficult to form gender congruent pairs across the trials without compromising the overlap condition. But due to the Swedish gender system requiring the use of the gender-marked definite article as a final inflection, it was possible to form the critical sets avoiding the mismatch with the preceding input cues (addressing the limitation in Chambers & Cooke (2009)). Moreover, although Russian has a grammatical gender system, it does not directly map onto the *common* versus *neuter* distinction of Swedish, that is why the Russian gender congruency was not considered for this study, but it could be addressed in the future follow-up research.

5.2.4 Pictures

Pictures were obtained from the International Picture Naming Project (IPNP) database (Bates et al., 2000), the Multilingual Picture Dataset (Duñabeitia et al., 2022), google or created digitally. They were grayscale and black and white drawings of 300x300 pixels in size. See Appendix D for an example of picture stimuli used in the task.

The initial set of pictures was developed with a Swedish native speaker, following which a picture naming task was run with thirteen Russian and eleven Swedish native speakers. The main aim of the task for this study was to understand whether participants would name the pictures in the intended way. If not, it was decided that a pre-experimental picture naming session would be added to the experimental session.

All the pictures in the naming task were presented in a randomized order. Two separate tests were run for each language group. The participants read the information sheet and signed their consent to take part in the experiment. They were administered the task in an online docs.google form. The noun set contained several pictures which could elicit the same noun to see which image would obtain the best score (such pictures were never used close to each other). When a participant gave the intended answer, it was coded as 1, while other responses received a score of 0. Although the overall accuracy based on each noun-picture naming score for Swedish and Russian reached 90% and 90.2% correspondingly, several critical nouns, which could not be changed due to the experimental design, stayed below 70%. Consequently, the decision was made to run a pre-experimental picture naming session to make sure that participants would be familiar with the intended names of the pictures in Swedish (Grüter et al., 2012; Hopp, 2013).

5.2.5 Sentence stimuli

96 critical sentences were created, so that half of them were semantically low constraining and the other half were highly constraining, i.e., biasing towards the target noun. 12 verbs (e.g., *se* (see)) or verb phrases (e.g., *titta på* (look at)) were chosen for the critical low-constraint sentences. The verbs were repeated four times throughout two experimental blocks in the critical trials. In the high-constraint sentences, verbs diverged depending on the noun. The present perfect simple tense was used in both critical and filler sentences, and the predicate consisted of a single verb or a verb with a particle, making the distance between the beginning of a sentence and a target noun onset equal to 3–4 words, similarly to Chambers & Cooke (2009).

Below is an example for two types of the critical sentences and a visual display (Figure 1) for the target *golv* [ˈɡɔlːv] (‘*floor*’ in English and ‘*пол*’ in Russian) competing with *berg* (‘*mountains*’ in English and ‘*горы*’ [ˈɡorɨ] in Russian. The high-constraint sentence (B) biased the listener towards the target noun “*golvet*” (the floor) because it is more plausible to polish the floor than the mountains while the low-constraint condition (A) left the choice open. The same low- and high-constraint sentences were used for each target noun across the eight conditions (see Table 1 for an example of eight conditions for the target noun GOLV and Appendix E for the list of all sentence stimuli).

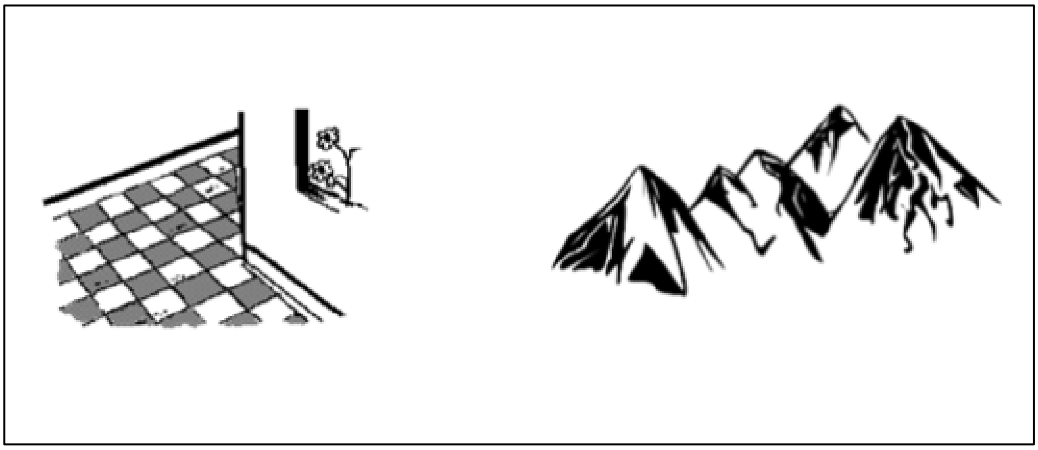

Figure 1. A visual display for the target GOLV competing with the Russian word for "mountains" (*горы* [ˈgori]).

A. Low constraint: Han har ritat golvet.
he.3SG. have-PRS. draw-PTCP floor-DEF.SG.N.
He has drawn the floor.

B. High constraint: Han har polerat golvet.
he.3SG. have-PRS. polish-PTCP floor-DEF.SG.N.
He has polished the floor.

In order to verify the low- and high-constraint context manipulations, twelve Swedish native speakers were asked to do a cloze probability task, answering online in writing which of the five pictures (a target and four competitors in randomised positions) could complete each sentence. One participant could not do the task with the low-constraint sentences due to technical problems. The results of the task were calculated by assigning 1 to the intended picture choice and 0 to any alternative choices (more than one in the high-constraint sentences and less than all in the low-constraint sentences). The participants chose the intended target picture 83.5% of the times in the high-constraint sentences and all the five pictures (demonstrating no bias towards any image) 93.6% of the times in the low-constraint sentence.[3]

[3] Despite the high overall accuracy, 10 high-constraint sentences had a rate below 70%. Consequently, all but 2 have been changed. The two sentences, altering which could render the verb overly complex, were: *Han har dragit ut* ***lådan****/panna/sångerska/båt/säng.* (He has pulled out the **drawer**/forehead/singer/boat/bed), where 62% of the answers were 'lådan', and *Hon har målat med* ***penseln****/sandlåda/nudlar/handskar/haj.* (She has painted with the **brush**/sandbox/noodles/gloves/shark) with a 54% accuracy rate.

Table 1. Eight experimental conditions for the target noun GOLV (floor).

Condition	Competition		Sentence context	Experimental sentence for GOLV (Russian translations of competitors are provided in quotation marks)
	L1 Russian phonological	L2 English cognate		
1.Low constraint, no competition	no overlap	non-cognate	low constraint	Han har ritat GOLVET / HUND. he.3SG. have-PRS. draw-PTCP floor-DEF.SG.N./dog-SG.C. He has drawn the floor/dog–‘sobaka’.
2. Low constraint, competition from English	no overlap	cognate	low constraint	Han har ritat GOLVET / TÄLT. he.3SG. have-PRS. draw-PTCP floor-DEF.SG.N./tent-SG.N. He has drawn the floor/tent–‘palatka’.
3. Low constraint, competition from Russian	overlap	non-cognate	low constraint	Han har ritat GOLVET / BERG. he.3SG. have-PRS. draw-PTCP floor-DEF.SG.N./mountain-PL.N. He has drawn the floor/mountains–‘gory’.
4. Low constraint, competition from Russian and English	overlap	cognate	low constraint	Han har ritat GOLVET / HUVUD. he.3SG. have-PRS. draw-PTCP floor-DEF.SG.N./head-SG.N. He has drawn the floor/head–‘golova’.
5. High constraint, no competition	no overlap	non-cognate	high constraint	Han har polerat GOLVET / HUND. he.3SG. have-PRS. polish-PTCP floor-DEF.SG.N./dog-SG.C. He has polished the floor/dog–‘sobaka’.
6. High constraint, competition from English	no overlap	cognate	high constraint	Han har polerat GOLVET / TÄLT. he.3SG. have-PRS. polish-PTCP floor-DEF.SG.N./tent-SG.N. He has polished the floor/tent–‘palatka’.
7. High constraint, competition from Russian	overlap	non-cognate	high constraint	Han har polerat GOLVET / BERG. he.3SG. have-PRS. polish-PTCP floor-DEF.SG.N./mountain-PL.N. He has polished the floor/mountains–‘gory’.
8. High constraint, competition from Russian and English	overlap	cognate	high constraint	Han har polerat GOLVET / HUVUD. he.3SG. have-PRS. polish-PTCP floor-DEF.SG.N./head-SG.N. He has polished the floor/head–‘golova’.

5.2.4 Other properties of the stimuli

Since the number of possible words matching the criteria is limited, the participants heard the target noun once in the low and once in the high-constraint sentence conditions but with different competitors and in a different block. To counterbalance, in the filler sentence trials, the same critical targets appeared twice as competitors, and all the critical competitors were used as targets two times. Target nouns in the filler trials were treated in the same way as the critical target nouns. Thus, every noun appeared an equal number of times during the experiment (Chabal & Marian, 2015).

192 filler trials also consisted of low- and high-constraint sentences and were compatible with the critical sentences in their syntactic structure (Dijkgraaf et al., 2017; Lagrou et al., 2015), but there was no phonological overlap across three translations of each filler target and competitor.

To ensure that participants were paying attention to the whole sentence instead of listening to the last word only, twenty-eight filler trials (fourteen per block) were followed by comprehension questions. The questions concerned a verb and required either "yes" or "no" answer 50% of the time each. To exemplify, after hearing *Hon har bakat brödet* (She has baked the bread), the question was *Har hon ätit brödet?* (Has she eaten the bread?) with the expected "*nej*" (no) answer.

48 quadruplets were created with each of the four conditions having 12 unique noun sets. Every participant heard 96 critical trials (12 target nouns per four conditions in two types of sentences) and 192 filler trials. Overall, each participant heard 288 trials divided into two blocks containing the same number of low- and high-constraint sentences.

Since the role of the filler trials was two-fold, that is to distract participants but also to make sure that each noun was repeated the same number of times, four experimental lists were created with an individual set of fillers which would fulfil the required conditions. The sentences were distributed across the four lists in a Latin-Square design and presented in two blocks in a pseudorandomized order making sure that no more than two target trials of the same condition were heard in a row (Shook et al., 2015). Additionally, attention was made not to have the same target noun or verb phrase heard in a row (there was, however, one verb which was heard sequentially in two filler trials in one list). The blocks never began or finished with a critical trial. The list order was counterbalanced in another four lists.

5.2.5 Auditory stimuli

All the experimental sentences were recorded at 44.1 kHz, 32 bits in a sound attenuating booth by a female adult Swedish native speaker using Audacity(R) recording and editing software in two sessions on two days. The sentences were divided into blocks containing auditory fillers which had a different syntactic structure helping to avoid the speaker adopting any monotone or accelerating prosody while reading alike sentences. The speaker was asked to use a declarative sentence intonation at a normal rate. The first three sentences appeared again at the end of each block and several sentences were recorded twice due to some noise in the initial recording[4]. The recordings were then processed using version 3.2.4 Audacity(R) recording and editing software; the target sentences were automatically marked; the volume was normalised with the perceived loudness of -23.0 LUFS (loudness units full scale) and the target noun onsets and sentence durations were obtained for both critical and filler trials.

5.3 Procedure

Participants were tested individually online, using the experiment created in PsychoPy (Peirce, Gray, Simpson, MacAskill, Höchenberger, Sogo, Kastman, & Lindeløv, 2019) version 2022.2.5 and hosted by Pavlovia (https://pavlovia.org/). Each meeting began with signing the consent form upon reading the information sheet and discussing any arising questions about the study. It was then followed by filling in the language background questionnaire LEAP-Q (Marian, Blumenfeld & Kaushanskaya, 2007) in Russian. The participants were told that the aim of the experiment was to see how well they could use their Swedish vocabulary in a Swedish listening comprehension task. After that, the participants had a picture naming session. In this session, the experimenter showed a picture on the shared computer screen using a PsychoPy built experiment and asked a participant in Swedish to name the picture. If a participant gave a wrong or no answer, the experimenter named the picture. Each picture naming session was compatible with an experimental list a participant would receive. The percentage of correct answers was considered for the participant's naming accuracy score.

After the picture naming session, the participants were encouraged to take a short break. Then, the experiment began. The experimenter monitored the whole experiment which lasted for approximately 20 minutes and was followed by the English and Swedish proficiency tests. Only then did the participants learn that their English knowledge was also relevant for the study. The English LexTALE (Lemhöfer & Broersma, 2012) was run online, and the Swedish version (Borg, 2021) was administered by the experimenter by sharing the screen and clicking "*ja*" (yes) or "*nej*" (no) buttons upon hearing the participant's response. Diverging from the original version, this way of running the test allowed for the whole meeting to be online. The entire meeting took around 90 minutes.

[4] Initially, high-constraint sentences were recorded with targets and with a nonce word *alagan* which was to be later replaced by a target from the other high-constraint sentence set. Similar to Shook et al. (2015), the aim was to avoid any possible target-biasing phonetic cues and to avoid elisions in *öppnat tändaren* (opened the lighter) and *restaurerat tavlan* (restored the painting) with the verb final -*t* and the noun initial *t*-. However, the resulting trials sounded unnatural. It was thus decided not to use the nonce word and record the two mentioned sentences with different predicates: *öppnat upp tändaren* (opened the lighter) and *hängt upp tavlan* (hung up the painting), which created meaningful high-constraint sentences (as confirmed by two Swedish native speakers).

In the main experiment, the participants read instructions in Swedish and then proceeded to three practice trials with feedback and eight practice trials without feedback. Each practice session had a comprehension question. The participants were instructed to select one of the two pictures which could complete a sentence as fast as possible without making mistakes. They used the right and left arrow keys on the keyboard to make their choice.

Every trial began with a fixation cross staying on the screen for 500ms, followed by a blank screen for another 500ms after which an auditory sentence was presented. Pictures appeared on the screen 1,000ms before the noun onset in each sentence (Lagrou et al., 2013b; Ito et al., 2018). Overall, picture presentation time used in previous studies ranges from 500ms (Bartolotti & Marian, 2018; Dijkgraaf et al., 2019) up to 2,000 – 2,200ms (Chambers & Cooke, 2009; Chun & Kaan, 2019). For this study, 1,000ms has been chosen as a time window which should be enough for participants to get familiar with the visual scene information, considering their multilingual background, which might result in slower processing (Shook et al., 2015; Dijkgraaf et al., 2019). The inter-trial interval was 500ms. The experimental blocks were divided by a self-timed break. The participants' reactions times, accuracy and answers to the comprehension questions were collected.

6. Results

The statistical analyses of accuracy and reaction times (RTs) were run in R, version 2022.07.2+576 (R Core Team, 2022), using the *lme4* package, version 1.1-31 (Bates et al., 2015), and *p*-values obtained using the *lmerTest* package, version 3.1-3 (Kuznetsova et al., 2020). The fixed effect factor of Sentence Constraint was contrast coded with the base condition (Low Constraint) as -0.5 and High Constraint as 0.5 (Linck & Cunnings, 2015). Based on previous research (Van Assche et al., 2011), Overlap and Cognate measures were treated as continuous variables, so that Overlap was coded based on the number of Russian-Swedish onset overlapping phonemes and Cognate was coded by virtue of the competitor's English-Swedish orthographic similarity score. Noncognates obtained the value of 0 to avoid them being treated as cognates based solely on their orthographic forms. All the continuous variables were mean-centred (Winter, 2019). Reaction times for the analysis were calculated by subtracting noun onset times from the corresponding trial raw reaction times. For data trimming, the resulting reaction times over 4,000ms and below 300ms were removed. Individual outlying values which were diverging from the participant's mean RTs by more or less than 3SD were also removed, resulting in the loss of 0.03% of the data altogether.

6.1 Comprehension questions and accuracy

Overall, the participants were highly accurate answering the comprehension questions, demonstrating that they were attentive and could understand the sentences sufficiently.

Mean comprehension question accuracy was 97.14% (*SD* = 5.78%; range = 71.43 – 100%). For the lexical selection task, only the accuracy in the critical trials was analysed. Incorrect responses were given a score of 0 and were excluded from the analysis of the RTs (0.8% of data loss) while each correct answer was coded as 1.

The generalised linear model with a binomial distribution was used to analyse the accuracy data. The model was progressively backwards-fit, sequentially removing the factors with insignificant effects (Covey et al., 2022). The initial model included Accuracy as the dependent variable and length of residence (LOR) in Russian, Swedish and English-speaking countries, amount of use of the three languages; participants' Age at the time of testing (included to see if the LOR effects were independent)[5]; English and Swedish LexTALE Scores; Picture naming accuracy (Naming Accuracy); Bilingualism; Number of languages; Block order; and the interaction of Overlap, Cognate and Sentence Constraint (Constraint) as fixed factors. The model converged with by-Item and by-Subject intercepts as random factors and the two-way interactions of Overlap and Cognate, Overlap and Constraint, and Cognate and Constraint as fixed factors. R-code: glmer(Accuracy ~ Overlap*Cognate + Overlap*Constraint + Cognate*Constraint + (1 | Subject) + (1 | Item)).

The results revealed a significant main effect of Overlap. The negative estimate (see Table 2) suggests that when a Swedish target overlapped with a competitor's Russian translation, participants' accuracy decreased (i.e., they erroneously chose a competitor significantly more often compared to when there was no cross-linguistic overlap). There was also a significant effect of Constraint, with participants making fewer errors in high-constraint sentences. There was no effect of competitors' L2 English L3 Swedish cognate status or the interaction of any factors, suggesting that the Overlap condition trials were responded to more erroneously regardless of the sentence context or the competitor's English-Swedish cognate status.

[5] For this study, experiential factors (i.e., length of residence and use) rather than age of acquisition (AoA) were considered for L2 English and L3 Swedish. Firstly, all but one participant acquired Swedish as late learners (which, however, does not necessarily or completely exclude the AoA effect and could be explored in the future). Importantly, most participants acquired Swedish upon their immigration, i.e., LOR in Sweden and in a Russian-speaking country, at least partially, reflect both AoA and immersion factors. Regarding English, although 34 out of 40 participants were first exposed to it at the age of ≤ 10 (i.e., as early learners), only 6 reported speaking English freely at the ages of 7 and 10 the earliest. Moreover, in the context of a Russian-speaking country, foreign language acquisition and use are typically limited to a classroom environment. Thus, considering the AoA of English for the current population requires additional discussion of what should be regarded as *acquisition* of a foreign language and whether in fact the learning experience rather than the age of acquisition or first exposure has a bigger effect. Consequently, since considering participants' characteristics was only additional to the main research questions informing the current study, the length of residence in Russian, English and Swedish-speaking countries were chosen to address the factors of exposure and experience with the three languages. In a follow-up study, it would be interesting to investigate the effects of the factors of AoA and learning experience with both foreign languages on cross-linguistic competition in the given population in more detail.

Table 2. Mixed-effects model results with accuracy score treated as the dependent variable.

	Fixed effects				Random effects	
	Estimate	Std. Error	*z value*	*p*	By Subject	By Items
					SD	*SD*
Intercept	6.452	0.581	11.106	<0.001***	1.46	0.7
Overlap	-0.667	0.209	-3.192	0.001**	–	–
Cognate	0.644	0.856	0.753	0.452	–	–
Constraint	1.057	0.534	1.982	0.048*	–	–
Overlap x Cognate	-0.201	0.637	-0.316	0.752	–	–
Overlap x Constraint	0.293	0.405	0.723	0.47	–	–
Cognate x Constraint	0.344	1.428	0.241	0.81	–	–
Note	In this and other models, the Overlap and Cognate factors reflect a mean-centred number of target-competitor Russian-Swedish overlapping phonemes and English-Swedish orthographic similarity score for cognate competitors. The Constraint factor reflects semantically low- and high-constraint sentences, coded as –0.5 for low- and 0.5 for high-constraint sentences. Formula: Accuracy ~ Overlap*Cognate + Overlap*Constraint + Cognate*Constraint + (1 | Subject) + (1 | Item). Significance codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.'					

6.2 Reaction times

The RT results were analysed using the *lmer*-function in R and the RTs were transformed using the log function (natural logarithm). All the fixed factors were coded and centred in the same way as for the Accuracy analysis described above. Similar to the Accuracy data analysis, initially all the factors which were of interest for the current research questions were included in the model and those factors which had no significant effect were progressively excluded. As a result, only the interaction of Overlap, Cognate and Constraint, and Naming Accuracy and Block order remained as fixed factors with the random effects of by-Subject and by-Item intercepts and slopes for Constraint. The final model formular (R-code): log(RTs) ~ Overlap*Cognate*Constraint + Naming Accuracy + Block order + (1+ Constraint | Subject) + (1+ Constraint | Item).

There was a significant main effect of Constraint, showing that reaction times were shorter for high compared to low-constraint sentences (see Table 3). The Block Order effect was also significant, reflecting that the participants sped up in the course of the task. Crucially, the effect of Overlap was also significant, suggesting that the participants were slower when more phonemes between a target and a competitor overlapped. Furthermore, while the competitor's English-Swedish Cognate effect was insignificant by itself, there was a marginally significant interaction of Overlap, Cognate and Constraint, which was further explored. The full model also showed that, expectedly, those participants who named more pictures before the experiment, were faster. No other factor effects were significant. See Figures 2–4 for the visualisation of predicted RTs plotted by the effects of Overlap, Sentence Constraint and the three-way interaction of Overlap, Cognate and Constraint.

Table 3. Mixed effects model results with reaction times (log-transformed) as the dependent variable.

	Fixed effects				Random effects	
	Estimate	Std. Error	*t value*	*p*	By Subject *SD*	By Items *SD*
Intercept	7.58	0.018	422.981	<0.001***	0.097	0.046
Overlap	0.004	0.002	2.237	0.025*	–	–
Cognate	-0.004	0.006	-0.59	0.555	–	–
Constraint	-0.046	0.009	-5.094	<0.001***	0.034	0.042
Naming accuracy	-0.002	0.0007	-3.338	0.002**	–	–
Block order	-0.038	0.004	-9.643	<0.001***	–	–
Overlap x Cognate	0.004	0.006	0.653	0.514	–	–
Overlap x Constraint	0.005	0.004	1.276	0.202	–	–
Cognate x Constraint	-0.013	0.013	-1.03	0.303	–	–
Overlap x Cognate x Constraint	0.019	0.012	1.658	0.097 .	–	–
Note	Formula: log(RTs) ~ Overlap*Cognate*Constraint + Naming Accuracy + Block order + (1 + Constraint | Subject) + (1 + Constraint | Item). Significance codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’					

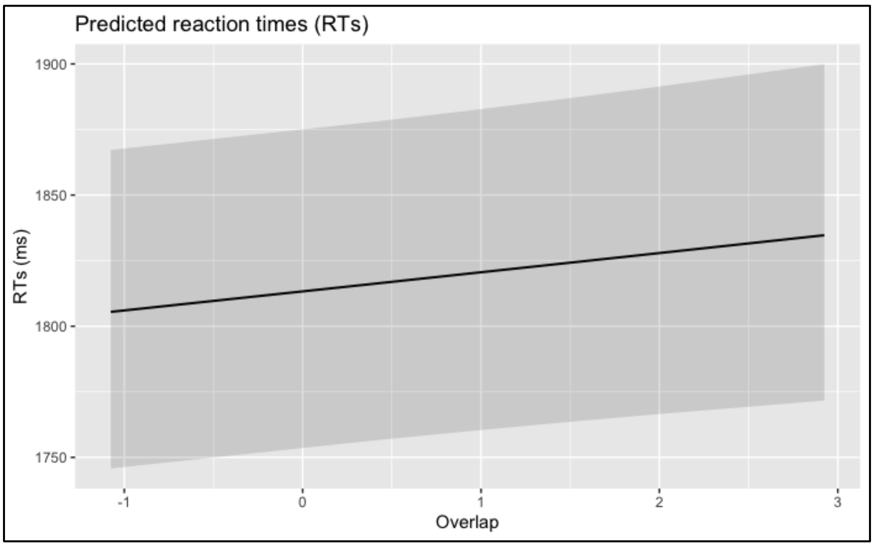

Figure 2. Predicted RTs plotted by the effect of Overlap (mean-centred numbers of overlapping phonemes, where -1 means no overlap).

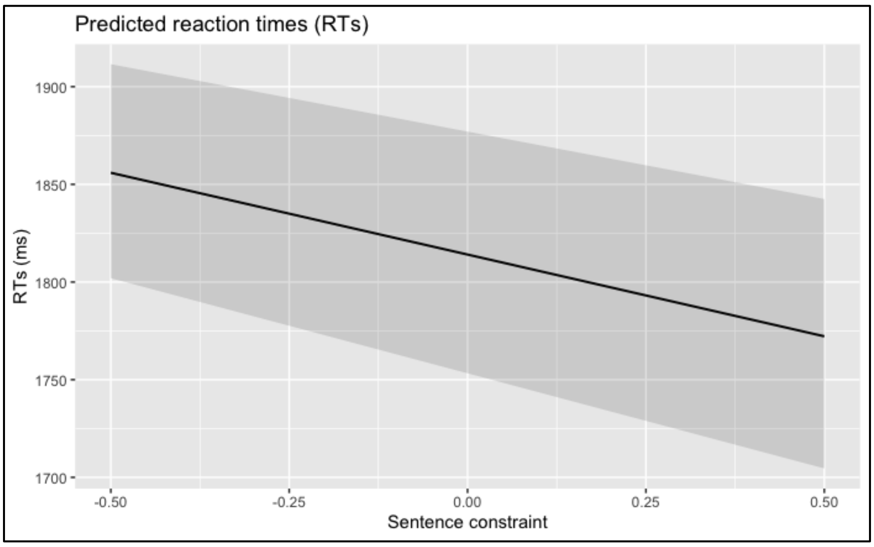

Figure 3. Predicted RTs plotted by the effect of Sentence Constraint (–0.50 refers to low- and 0.50 to high-constraint sentences).

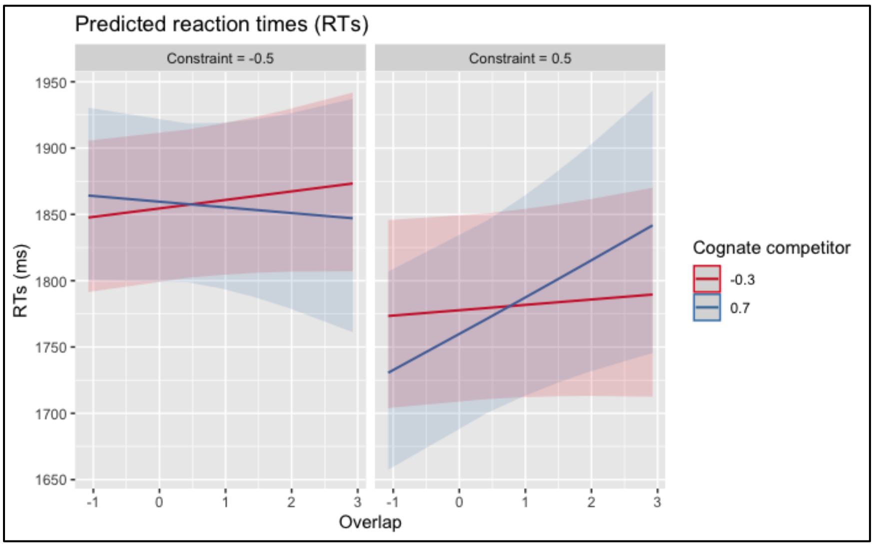

Figure 4. Predicted RTs plotted by the effect of the interaction of Overlap (mean-centred numbers of overlapping phonemes), Cognate (mean-centred orthographic similarity score where -0.3 and 0.7 reflect the scores of 0, i.e., noncognates, and 1, i.e., identical cognates) and Constraint (–0.50 refers to low- and 0.50 to high-constraint sentences).

6.2.1 Follow-up analyses

6.2.1.1 Low constraint conditions

To explore the three-way interaction, two separate models were run for each level of the factor of Constraint using the same backwards-fit principle. For the Low Constraint conditions, the random effects included by-Item intercepts and by-Subject intercepts and slopes for the Overlap measures, in addition to the fixed effects of LOR in a Russian-speaking country (LORR), Age, Naming Accuracy and Block order. R-code: lmer(log(RTs) ~ Overlap*Cognate + LORR + Age + Naming Accuracy + Block order + (1 + Overlap | Subject) + (1 | Item).

Table 4. Mixed-effects model results for the Low Constraint conditions with reaction times (log-transformed) treated as the dependent variable.

	Fixed effects				Random effects	
	Estimate	Std. Error	*t value*	*p*	By Subject *SD*	By Items *SD*
Intercept	7.604	0.015	521.409	<0.001***	0.064	0.044
Overlap	0.002	0.003	0.645	0.522	0.008	–
Cognate	0.002	0.008	0.202	0.84	–	–
LORR	0.003	0.002	2.150	0.038*	–	–
Age	0.003	0.001	2.451	0.019*	–	–
Naming accuracy	-0.003	6.9e-04	-4.647	<0.001***	–	–
Block order	-0.039	0.005	-7.294	<0.001***	–	–
Overlap x Cognate	-0.005	0.008	-0.671	0.502	–	–
Note	Formula: log(RTs) ~ Overlap*Cognate + LORR + Age+ Naming Accuracy + Block order + (1+ Overlap | Subject) + (1 | Item). Significance codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.'					

Neither Overlap, nor Cognate factors or their interaction had a significant effect on reaction times in low-constraint sentences. The Age factor had a slightly bigger effect than LOR in a Russian-speaking country (LORR), whose effect, nevertheless, was also significant (see Table 4), suggesting that both factors made the participants slower. To sum-up, no cross-linguistic competition effect was significant in low-constraint sentences.

6.2.1.2 High constraint conditions

As before, all the factors which did not show a significant effect were sequentially removed from the model for the High Constraint conditions (except for the Cognate and Age factors for the purpose of comparison between the Low and High Constraint models), resulting in the inclusion of the fixed effects of LOR in a Russian-speaking country (LORR), Age, Naming Accuracy, Block order, the interaction between Overlap and Cognate, in addition to by-Subject and by-Item intercepts as random factors. R-code: lmer(log(RTs) ~ Overlap*Cognate + LORR + Age + Naming Accuracy + Block order + (1 | Subject) + (1 | Item)).

In high-constraint sentences, the effect of Overlap was significant (see Table 5), showing that when an L3 Swedish target phonologically overlapped with an L1 Russian competitor's translation, the participants selected a target noun picture significantly more slowly. However, the interaction between the factors of Overlap and Cognate did not reach the level of significance. Neither did L2 English interference alone yield a significant effect, which might explain the weak Overlap-Cognate interaction effect. The only LOR which remained significant, was related to Russian, showing that a longer stay in an L1-speaking environment (which also meant later L3 immersion) significantly slowed participants down in high-constraint sentences regardless of their age, whose effect was insignificant. This is interesting, considering the strong L1 Russian phonological competition effect but weak L2 English interference.

To sum up, semantically highly constraining sentences were processed faster than low-constraint sentences across the board, having the main facilitative effect on the reaction times in the task. In the trials where an L3 Swedish target phonologically overlapped with a competitor's L1 Russian translation, the participants reacted more slowly than in the no overlap trials. This demonstrates that L1 Russian interfered in the course of an L3 monolingual task even when the context reliably biased the participants towards a target. Moreover, somewhat surprisingly, the cross-linguistic phonological Overlap effect was significant only in high-constraint sentences, which also experienced the strongest effect of LOR in a Russian-speaking country regardless of the actual Age factor. A longer stay in an L1-speaking environment or the resulting later L3 immersion onset made the participants slower. However, the competitor's L2 English L3 Swedish Cognate factor did not yield a significant effect by itself but interacted with L1 Overlap and Sentence Constraint, suggesting that the participants experienced bigger double non-target language competition in high- compared to low-constraint sentences. However, the further analyses revealed that the size of the double competition effect did not reach significance in either sentence context. From all the participants' individual characteristics, only LOR in a Russian-speaking country yielded a significant effect even when age, Swedish and English proficiency and use were considered.

Table 5. Mixed-effects model results with reaction times treated as the dependent variable (log-transformed). High Constraint conditions.

	Fixed effects				Random effects	
	Estimate	Std. Error	*t value*	*p*	By Subject	By Items
					SD	*SD*
Intercept	7.557	0.018	413.548	<0.001***	0.085	0.057
Overlap	0.006	0.003	2.327	0.02*	–	–
Cognate	-0.009	0.009	-0.975	0.33	–	–
LORR	0.006	0.002	2.723	0.0095**	–	–
Age	0.003	0.002	1.600	0.117		
Naming accuracy	-0.004	9.2e-04	-4.047	<0.001***	–	–
Block order	-0.038	0.006	-6.428	<0.001***	–	–
Overlap x Cognate	0.012	0.009	1.431	0.153	–	–
Note	Formula: log(RTs) ~ Overlap *Cognate + LORR + Age + Naming Accuracy + Block Order + (1|Subject) + (1|Item). Significance codes: 0 '***' 0.001'**'0.01 '*'0.05 '.'					

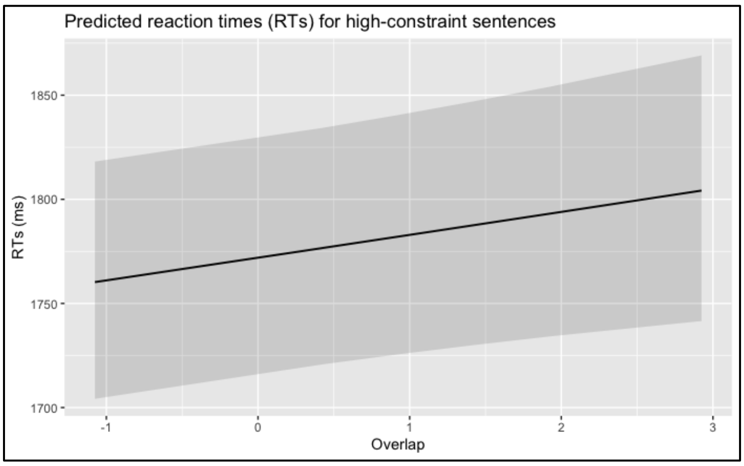

Figure 5. Predicted RTs plotted by the effect of Overlap (mean-centred numbers of overlapping phonemes, where -1 means no overlap).

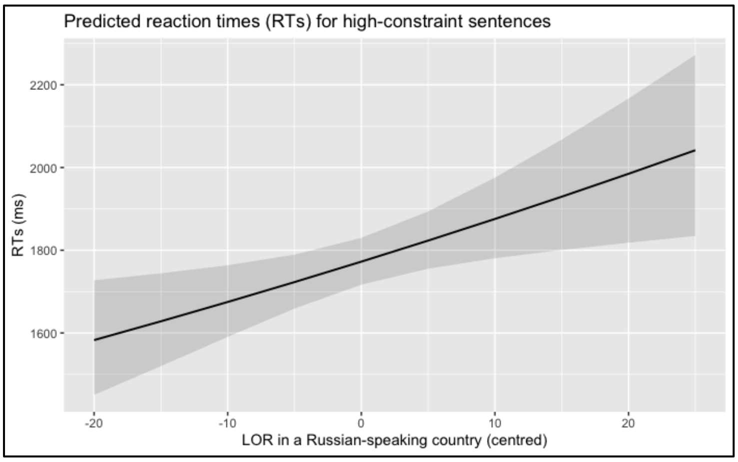

Figure 6. Predicted RTs plotted by the effect of Length of Residence (LOR) in a Russian-speaking country (mean-centred).

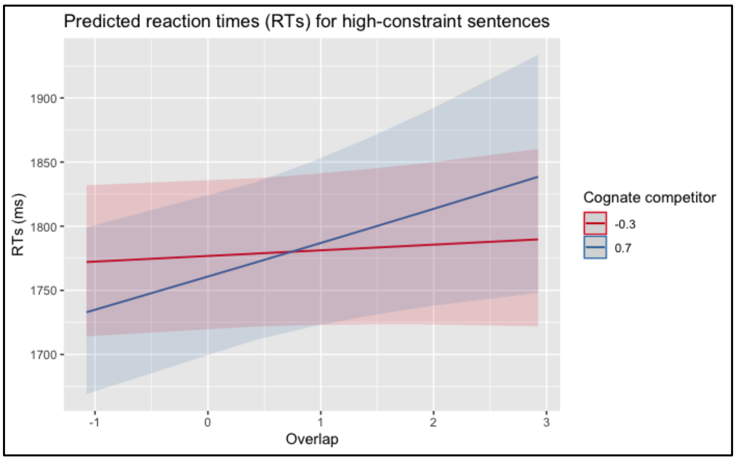

Figure 7. Predicted RTs plotted by the effect of the interaction of Overlap (mean-centred numbers of overlapping phonemes, where -1 means no overlap) and Cognate competitor (mean-centred orthographic similarity score, where -0.3 and 0.7 reflect the scores of 0, i.e., noncognates, and 1, i.e., identical cognates).

7. Discussion

The current study aimed to investigate whether L1 Russian L2 English L3 Swedish learners (with a late age of L3 acquisition) would experience competition from one or two non-target languages when listening to semantically low- and high-constraint sentences in their L3 Swedish while doing an online lexical selection task. The sentence context (as determined by the main verb) was manipulated to be either low or highly constraining, so that the high-constraint sentences would bias towards the target noun. The cross-linguistic competition was explored by choosing a competitor whose L1 Russian translation phonologically overlapped with an L3 Swedish target and/or a competitor which was an L2 English L3 Swedish cognate. The study explored whether top-down information from semantically highly constraining L3 Swedish sentences could modulate cross-linguistic competition of varying kinds (phonological overlap or cognate interference) and degrees (from one or two non-target languages). Finally, the influence of participants' individual characteristics on L3 auditory comprehension was investigated.

The results suggest that a semantically constraining sentential context in L3 Swedish led to more accurate and faster lexical selection compared to the low constraining context. However, sentence bias did not eliminate bottom-up driven competition from the participants' L1 Russian, which was found to interfere in high-constraint sentences even when only the end-course reaction times were analysed. The L1 Russian interference also made the participants significantly less accurate when selecting a target over a competitor in both sentence contexts. Conversely, single L2 English interference did not yield a significant effect. There was only a marginal effect of the three-way interaction of L1 Russian phonological Overlap, L2 English L3 Swedish Cognate and Sentence Constraint factors, which was explored in the follow-up analyses. As a result, no significant double non-target language (L1 and L2) interference was observed in each sentence type.

The high-constraint sentence context affected reaction times, reliably helping the participants to select a target picture faster. It also impacted accuracy, such that when the sentential context was biasing towards the target noun, the participants made fewer errors when selecting the target (and ignoring the competitor). In fact, after the experiment, most participants admitted having noticed the sentence constraint. The findings are consistent with previous studies which have demonstrated that multilinguals can use the preceding semantic context in their foreign language(s) to make a lexical decision faster and more accurately, similarly to native and monolingual speakers, albeit less efficiently (Shook et al., 2015; Dijkgraaf et al., 2019). Below we interpret these findings in light of the research questions that inform the study.

The first research question concerned the interference from L1 Russian: Does participants' L1 Russian get activated during an auditory lexical selection task in their L3 Swedish? The L1 Russian interference impacted both reaction times and accuracy, resulting in slower processing and significantly lower accuracy, which is in line with previous findings that demonstrate a strong competition effect from participants' L1 (Marian & Spivey, 2003). Since it was found in high-constraint sentences only, the L1 interference effect will be discussed in more detail when we address the third research question.

The second research question concerned the participants' L2 English interference: Does participants' L2 English get activated during an auditory lexical selection task in their L3 Swedish and does it modulate the potential L1 Russian activation? The results suggest that L2 English interference by itself did not significantly affect L3 Swedish comprehension with respect to both reaction times and accuracy. Although it did interact with the observed L1 interference and sentence constraint, as suggested by a marginal three-way interaction, the follow-up analyses did not reveal an effect of L2 interference.

These findings do not support the prediction that different kinds of competition from non-target L1 and L2 would result in cumulative, double cross-linguistic interference in the L3 sentence context. It appears that only overt L1 phonological competition made the participants significantly slower and less accurate while L2 English interference (from an L2 English L3 Swedish cognate competitor) was never strong enough. The competition from L2 English was covert because it did not match L3 Swedish input directly but could potentially be triggered by the spread activation from the visual scene information (a picture whose labels were English-Swedish cognates) or/and from the initial overt L1 competition from competitors' Russian translations which phonologically overlapped with L3 Swedish input (target nouns). The current results thus diverge from the findings by Shook & Marian (2019) who observed a significant covert co-activation effect at the word level processing.

Firstly, this pattern can be the result of the L2 not only being a non-target language in the task, but also the language which was not used during the experimental meeting before the main task. The participants were told that they had to be native speakers of Russian and late learners of Swedish. They were unaware that English was also relevant. However, although the effect of the prior language context has been observed in some studies (Spivey & Marian, 1999; Mercier et al., 2016), it has not always been found in the others (Lemhöfer et al., 2004). It is possible that since our trilingual participants have, generally, been using all their three languages daily but in different contexts, they might have been more sensitive to the absence of L2 English prior to the main task, but at this point, this assumption cannot be directly supported by the findings considering the experimental set-up used. It would, consequently, be interesting to explore the priming effect of the prior L2 use in a follow-up study.

It is, however, doubtful that the weak L2 effect was due to low proficiency, because the participants were, on average, similarly advanced in both Swedish and English with the mean LexTALE scores of 76.8 and 74.1, respectively. Moreover, the L2 or L3 proficiency effect was earlier found in relation to the L2 and L3 interference when processing the first (i.e., more dominant, earliest acquired and possibly most proficient) language (Szubko-Sitarek, 2011; Van Hell & Dijkstra, 2002) but in this study, the participants were listening to their third, latest acquired language. Nevertheless, our participants, generally, used their L2 English less frequently (23.2%) than L1 and L3 – 36.4% and 31.9% for L1 Russian and L3 Swedish, respectively. However, the effect of the language use of either language did not reach significance in any of the statistical models, meaning that the factor was not able to explain the differences in the performance.

Another possibility is that the L2 influence in this study was insufficient because the L2-L3 cognates were mostly nonidentical. Although the same cognateness measure as the one used for this study had yielded significant effects of cognateness in previous research (Kurnik, 2016), the trilingual status of the participants and the auditory task modality could have affected the performance differently. Finally, it is also possible that looking at the end-course reaction times did not allow to capture the L2 interference effect, which otherwise could have been observed in earlier processing measures.

Interestingly, the L2 English interference was weaker than the L1 Russian competition, although English and Swedish are cross-linguistically closer. Similarly, Grüter & Hopp (2021) found that cross-linguistic effects at the level of the syntax were explained by the order of acquisition of the participants' two languages, but not by the amount of use of each language. The current findings might suggest that acquisition order can also prevail over the languages' cross-linguistic (dis)similarity, although this question requires further investigation with more sensitive measuring techniques (eye-tracking or EEG), for instance, to see whether a typologically related but more dominant L2 than L1 will interfere in L3 comprehension.

The third research question concerned the interaction between top-down information and cross-linguistic competition: To what extent does top-down information (i.e., sentence constraint) modulate the potential cross-linguistic competition from L1 Russian and/or L2 English with L3 Swedish? The results suggest that even though the high-constraint sentence context helped the participants to select a Swedish target faster and more accurately, competition from L1 Russian stayed robust. A surprising finding is that there was no cross-linguistic competition effect in low-constraint sentences, which might be explained by generally longer response times in such trials. In turn, this could have failed to capture effects of cross-linguistic competition by the time participants selected the target (Huettig & McQueen, 2007). Previous studies using more sensitive measures (e.g., first-pass fixations or event-related potentials) were able to capture effects of cross-linguistic competition (Chambers & Cooke, 2009; Wu & Thierry, 2010). The proposed explanation is supported by the absence of any Overlap-Constraint interaction effect on Accuracy, meaning that phonologically overlapping competitors deceivably attracted more attention in both types of sentences. Alternatively, it is possible that the Russian-Swedish phonologically target-overlapping competitor became more disruptive in the context where the target was expected, increasing the competition effect, but such an account would contradict numerous (if not all) previous studies and, thus, seems implausible.

Interestingly, the L1 Russian L3 Swedish phonological overlap competition was significant even though only the end-course reaction times were explored, which appears to contradict several previous studies on bilinguals. For instance, Ito et al. (2018) did not find any L1 Japanese phonological interference for their Japanese-English listeners of semantically constraining sentences in English, and Chambers and Cooke (2009) observed the dominant English language interference in low-constraining sentences being significantly modulated in competitor incompatible contexts.

The differences across the findings in the three studies can be explained by several factors. Firstly, the complete absence of Japanese interference in Ito et al. (2018) might well be explained by Japanese and English being too cross-linguistically dissimilar to elicit any visible co-activation. Secondly, the current study recruited almost twice as many participants, resulting in different statistical power. Thirdly, the decision to counterbalance target-competitor gender congruency might have influenced the results in Chambers and Cooke (2009), particularly, in competitor incompatible sentences by providing an even stronger target-biasing cue to the listeners.

Ito et al. (2018) also suggest that their use of English prior to the experiment might have reduced any potential Japanese influence. It is not reported which language was used in Chambers and Cooke (2009). As mentioned earlier, the participants in this study used both Russian (in the language background questionnaire) and Swedish when naming the picture stimuli *directly* before doing a monolingual Swedish task. It thus appears unlikely that Russian was primed more than Swedish. Furthermore, the differences in the methods should also be considered.

Finally, the diverging results can also be explained by the fact that our participants were processing their L3 while in the above-mentioned research, the subjects were reading in or listening to their L2. The third language could have experienced bigger competition from the first, much earlier acquired language, than the second language did. Future studies should explore this possibility, for example, by comparing if the same trilingual speakers would experience a smaller L1 competition effect when processing their L2 compared to L3 (with the same L2 and L3 use). In any case, the fact that L1 competition was observed in the end-course reaction times reveals the strength of its interference effect, which has, indeed, been found even in semantically rich sentences in other studies (Lagrou et al., 2013a, b; 2015; Van Assche et al., 2011; Kurnik, 2016).

However, our findings diverge from the only trilingual sentential study to date conducted by Lijewska (2022) who found no cognate facilitation effect in semantically low- or high-constraint English (foreign language) sentences even though the critical words were cognates across the participants' three languages. This suggests that even L1 co-activation in non-native visual language comprehension was absent, which diverges from the current findings. However, the two studies differ significantly: auditory versus visual language processing; different measures of cognateness; and the status of two foreign languages in Lijewska (2022) was mixed, meaning that some of the participants were processing their L2, not their L3. In the current study, the order of L2 and L3 acquisition was controlled for. The participants' backgrounds were also different: while our subjects were immersed in their L3 Swedish and possibly L2 English environments (due to the wide English use in Sweden), Lijewska (2022)'s subjects were living in the L1 Polish-speaking community where neither German nor English (L2/L3) were widely used. Moreover, the cognate effect predicted in this study was impeding (cognates being competitors) but not facilitative (cognates being targets) as in the 2022. More evidence is needed to understand which of the above factor(s) has the biggest influence.

Regarding individual characteristics of participants, only the length of residence in a Russian-speaking country had a significant effect (independent of the age factor), showing that a longer stay in an L1-speaking environment (which also meant later immersion in the L3 context) slowed down L3 Swedish listeners, particularly, in high-constraint conditions. Interestingly, neither proficiency, exposure, nor use of Swedish affected accuracy or reaction times. However, those participants who could name more pictures in Swedish, reacted faster. The influence of L1 Russian on L3 Swedish speech comprehension was strong across the board even though the participants used both languages similarly often and were living in Sweden. On the one hand, the results differ from earlier findings that the language of the environment can modulate non-target language competition (Spivey & Marian, 1999); on the other, the linguistic environment of the current participants could have been different, providing them more opportunities to use all their three languages than, e.g., the US context in Spivey & Marian (1999).

To conclude, the results of the study are inconsistent with the assumption of the BIA+ model that top-down information can modulate bottom-up guided cross-linguistic co-activation even at later processing stages. Although BIA+ focuses on visual language processing of bilinguals but not auditory comprehension of trilinguals, its predictions have been applied to both scenarios before (Lagrou et al., 2013a; Lijewska, 2022). However, the pattern of results is in line with BLINCS which assumes that cross-linguistic co-activation of input-matching candidates decays gradually, as the input is presented, and leaves a trace from previously processed elements. Moreover, the information from a visual scene can directly affect linguistic processing, potentially triggering the activation of picture labels in all the languages. Nevertheless, the model does not directly make predictions for the influence of top-down information in sentence contexts. Consequently, it appears necessary to expand both models to include not only bilingual but also generally multilingual population and possibly moderate and/or include the assumptions regarding the interaction between top-down and bottom-up processes.

8. Conclusions

The findings of the study suggest that L1 Russian L2 English late L3 Swedish learners could use rich sentential semantic cues to facilitate their online Swedish speech comprehension. However, top-down information did not modulate cross-linguistic competition from the listeners' first language, making them slower and less accurate in the presence of this competition. The results do not support the prediction of the BIA+ model that top-down information can modulate lexical access selectivity at later processing stages. The observed pattern may be explained by order of acquisition, with the first acquired language interfering with the target L3, even if the learners had been immersed in their L3 speaking environment for several years.

The findings are more consistent with the BLINCS model, which captures cross-linguistic co-activation from multiple representational levels, gradually decaying as the input unfolds, and considers visual scene input information. BLINCS also assumes a possibility of double non-target language competition. But since the L2 co-activation did not yield an effect which would be strong enough to be captured in the end-course reaction times, more research is needed to understand whether it would be more visible during the earlier processing stages and what factors could modulate it. Finally, the results suggest that only the residence in an L1-speaking country, providing more exposure to L1 and delaying the L3 immersion, but not L2 or L3 immersion time, use or proficiency affected L3 speech processing, making it slower.

While the paradigm used in this research has proven to be useful to elicit not only multiple-layer interactions across several languages but also the relation between the top-down and bottom-up processes in a multilingual brain, along with several limitations, there are still questions to be addressed in the future. Regarding the limitations, possibly the biggest one is analysing the end-course reaction times, which might be responsible for the lack of cross-linguistic effects in the low-constraint sentences. More sensitive measuring techniques, e.g., eye-tracking or EEG could help herewith. Additionally, the online set-up provides less researcher control over the experimental environment than the in-person testing. Finally, but not exhaustively, the ranges of the participants' age and length of residence were quite wide, and although the sample size was relatively large for similar studies, an even bigger number of subjects would provide a clearer picture.

The current study did not include a control group for two reasons. Firstly, at this stage, the main goal was to investigate diverse multiple layer interactions within the same mental lexicon, making a within-group comparison sufficient. Secondly, it might be next to impossible to find enough monolingual Swedish speakers matching all the experimental criteria. However, in the future, Swedish-English speakers could be recruited as a 'partially' control group.

There are several directions which a follow-up study can take. Firstly, the effect of the unstressed vowel reduction on L1 Russian competition (discussed in the Materials section) can be explored to understand whether phonological competition is primarily guided by the reduced unstressed phonological or unreduced orthographic forms of the corresponding nouns. Additionally, the relative roles of cross-linguistic (dis)similarities and the order and kind of acquisition across three languages need more exploration as well as whether L2 and L3 interfere with online L1 comprehension. A different direction can be taken to investigate whether grammatical gender congruency (within and across languages) can affect lexical cross-linguistic competition. Since Russian and Swedish both have grammatical gender systems, an interesting set-up can be developed. Finally, the influence of the preceding language context on both non-target languages' co-activation can also be explored.

References

Alemán Bañón, J., & Clara, M. (2021). The role of crosslinguistic differences in second language anticipatory processing: An event-related potentials study. *Neuropsychologia,* 155, 107797. https://doi.org/10.1016/j.neuropsychologia.2021.107797.

Allopenna, P.D., Magnuson, J.S., & Tanenhaus, M.K. (1998). Tracking the Time Course of Spoken Word Recognition Using Eye Movements: Evidence for Continuous Mapping Models. *Journal of Memory and Language,* 38(4), 419–439. https://doi.org/10.1006/jmla.1997.2558.

Antón, E., Fernández-García, Y., Carreiras, M., & Duñabeitia, J.A. (2016). Does bilingualism shape inhibitory control in the elderly? *Journal of Memory and Language,* 90, 147–160. https://doi.org/10.1016/j.jml.2016.04.007.

Bardel, C., & Falk, Y. (2007). The role of the second language in third language acquisition: the case of Germanic syntax. *Second Language Research*, 23(4), 459–484. https://doi.org/10.1177/0267658307080557.

Bartolotti, J., & Marian, V. (2018). Learning and processing of orthography-to-phonology mappings in a third language. *International Journal of Multilingualism*, 16(4), 377–397. Routledge. https://doi.org/10.1080/14790718.2017.1423073.

Batel, E. (2020). Context Effect on L2 Word Recognition: Visual Versus Auditory Modalities. *Journal of Psycholinguistic Research,* 49(2), 223–245. https://doi.org/10.1007/s10936-019-09683-6.

Bates, E., Andonova, E., D'Amico, S., Jacobsen, T., Kohnert, K., Lu, C., & Pleh, C. (2000). Introducing the CRL international picture naming project (CRL-IPNP). Center for Research in Language Newsletter 2000. 12(1).

Bates, D., Mächler, M., Bolker, B., & Walker, S. (2015). Fitting Linear Mixed-Effects Models Using lme4. *Journal of Statistical Software*, 67(1), 1–48. doi:10.18637/jss.v067.i01.

Batsuren, K., Bella, G., & Giunchiglia, F. (2019). CogNet: A Large-Scale Cognate Database. In *Proceedings of the 57th Annual Meeting of the Association for Computational Linguistics*, 3136–3145. Florence, Italy: Association for Computational Linguistics. https://doi.org/10.18653/v1/P19-1302.

Batsuren, K., Bella, G., & Giunchiglia, F. (2022). A large and evolving cognate database. *Language Resources & Evaluation*, 56(1), 165–189. https://doi.org/10.1007/s10579-021-09544-6.

Bialystok, E. (2009). Bilingualism: The good, the bad, and the indifferent. *Bilingualism: Language and Cognition,* 12(1), 3–11. https://doi.org/10.1017/S1366728908003477.

Blank, C. A., & Llama, R. (2019). Exploring Learning Context Effects and Grapho(-Phonic)-Phonological Priming in Trilinguals. *Languages,* 4(3), 61. https://doi.org/10.3390/languages4030061.

Blumenfeld, H.K., & Marian, V. (2007). Constraints on parallel activation in bilingual spoken language processing: Examining proficiency and lexical status using eye-tracking. *Language and Cognitive Processes,* 22(5), 633–660. https://doi.org/10.1080/01690960601000746.

Borg, R. (2021). *Facilitative Online Processing of Gender in Swedish as a Second Language*. Retrieved from http://urn.kb.se/resolve?urn=urn:nbn:se:su:diva-199824.

Burgess, C., & Lund, K. (1997). Modelling parsing constraints with high-dimensional context space. *Language & Cognitive Processes,* 12(2), 177–210. https://doi.org/10.1080/016909697386844.

Bylund, E., Antfolk, J., Abrahamsson, N., Haug Olstad, A.M., Norrman, G. & Lehtonen, M. (2022). Does bilingualism come with linguistic costs? A meta-analytic review of the bilingual lexical deficit. *Psychonomic Bulletin & Review*. https://doi.org/10.3758/s13423-022-02136-7.

Carreiras, M., Ferrand, L., Grainger, J., & Perea, M. (2005). Sequential Effects of Phonological Priming in Visual Word Recognition. *Psychological Science*, 16(8), 585–589. https://doi.org/10.1111/j.1467-9280.2005.01579.x.

Chabal, S., & Marian, V. (2015). Speakers of different languages process the visual world differently. *Journal of Experimental Psychology: General*, 144(3), 539–550. https://doi.org/10.1037/xge0000075.

Chambers, C.G., & Cooke, H. (2009). Lexical competition during second-language listening: Sentence context, but not proficiency, constrains interference from the native lexicon. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 35(4), 1029–1040. https://doi.org/10.1037/a0015901.

Chun, E., & Kaan, E. (2019). L2 Prediction during complex sentence processing. *Journal of Cultural Cognitive Science*, 3(2), 203–216. https://doi.org/10.1007/s41809-019-00038-0.

Corbett, Greville G. (1991). *Gender*. Cambridge University Press.

Covey, L., Fiorentino, R., & Gabriele, A. (2022). Island sensitivity in L2 learners: Evidence from acceptability judgments and event-related potentials. *Second Language Research*. https://doi.org/10.1177/02676583221116039.

Cutler, A. (2012). *Native listening: language experience and the recognition of spoken words*. Cambridge, Massachusetts: The MIT Press.

Dahan, D., & Magnuson, J.S. (2006). Spoken Word Recognition. In Matthew J. Traxler & Morton A. Gernsbacher (eds.), *Handbook of Psycholinguistics.* (2nd ed.). pp. 249–283. London: Academic Press. https://doi.org/10.1016/B978-012369374-7/50009-2.

Dahan, D., Magnuson, J.S., & Tanenhaus, M.K. (2001). Time course of frequency effects in spoken-word recognition: evidence from eye movements. *Cognitive Psychology*, 42(4), 317–367. https://doi.org/10.1006/cogp.2001.0750.

De Angelis, G. (2007). *Third or Additional Language Acquisition*. Multilingual Matters. https://doi.org/10.21832/9781847690050.

Desroches, A.S., Newman, R.L., & Joanisse, M.F. (2009). Investigating the Time Course of Spoken Word Recognition: Electrophysiological Evidence for the Influences of Phonological Similarity. *Journal of Cognitive Neuroscience*, 21(10), 1893–1906. https://doi.org/10.1162/jocn.2008.21142.

Dijkgraaf, A., Hartsuiker, R.J., & Duyck, W. (2017). Predicting upcoming information in native-language and non-native-language auditory word recognition. *Bilingualism: Language and Cognition*, 20(5), 917–930. https://doi.org/10.1017/S1366728916000547.

Dijkgraaf, A., Hartsuiker, R.J., & Duyck, W. (2019). Prediction and integration of semantics during L2 and L1 listening. *Language, Cognition and Neuroscience*, 34(7), 881–900. https://doi.org/10.1080/23273798.2019.1591469.

Dijkstra, T., Van Hell, J.G., & Brenders, P. (2015). Sentence context effects in bilingual word recognition: Cognate status, sentence language, and semantic constraint. *Bilingualism: Language and Cognition*, 18(4), 597–613. https://doi.org/10.1017/S1366728914000388.

Dijkstra, T., & Van Heuven, W.J.B. (1998). The BIA model and bilingual word recognition. In *Localist connectionist approaches to human cognition.* (pp. 189–225). Lawrence Erlbaum Associates Publishers.

Dijkstra, T., & Van Heuven, W.J.B. (2002). The architecture of the bilingual word recognition system: From identification to decision. *Bilingualism: Language and Cognition*, 5(3), 175–197. https://doi.org/10.1017/S1366728902003012.

Dijkstra, T., Wahl, A., Buytenhuijs, F., Van Halem, N., Al-Jibouri, Z., De Korte, M., & Rekké, S. (2019). Multilink: A computational model for bilingual word recognition and word translation. *Bilingualism: Language and Cognition*, 22, 657–679. https://doi.org/10.1017/S1366728918000287.

Duñabeitia, J.A., Baciero, A., Antoniou, K., Antoniou, M., Ataman, E., Baus, C., Ben-Shachar, M., et al. (2022). The Multilingual Picture Database. *Scientific Data*, 9(1), 431. https://doi.org/10.1038/s41597-022-01552-7.

Duñabeitia, J.A., Hernández, J.A., Antón, E., Macizo, P., Estévez, A., Fuentes, L.J., & Carreiras, M. (2014). The inhibitory advantage in bilingual children revisited: myth or reality? *Experimental Psychology*, 61(3), 234–251. https://doi.org/10.1027/1618-3169/a000243.

Duyck, W., Van Assche, E., Drieghe, D., & Hartsuiker, R.J. (2007). Visual word recognition by bilinguals in a sentence context: Evidence for nonselective lexical access. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 33, 663–679. https://doi.org/10.1037/0278-7393.33.4.663.

Frauenfelder, U.H., & Komisarjevsky Tyler, L. (1987). The process of spoken word recognition: An introduction. *Cognition (Special Issue Spoken Word Recognition)*, 25(1), 1–20. https://doi.org/10.1016/0010-0277(87)90002-3.

Garlock, V.M., Walley, A.C., & Metsala, J.L. (2001). Age-of-Acquisition, Word Frequency, and Neighborhood Density Effects on Spoken Word Recognition by Children and Adults. *Journal of Memory and Language*, 45(3), 468–492. https://doi.org/10.1006/jmla.2000.2784.

Gollan, T.H., Montoya, R.I., Cera, C., & Sandoval, T.C. (2008). More use almost always a means a smaller frequency effect: Aging, bilingualism, and the weaker links hypothesis. *Journal of memory and language*, 58(3), 787–814. https://doi.org/10.1016/j.jml.2007.07.001.

Gollan, T.H., Slattery, T.J., Goldenberg, D., Van Assche, E., Duyck, W., & Rayner, K. (2011). Frequency drives lexical access in reading but not in speaking: The frequency-lag hypothesis. *Journal of Experimental Psychology: General*, 140, 186–209. https://doi.org/10.1037/a0022256.

Grosjean, F. (1985). The bilingual as a competent but specific speaker-hearer. *Multilingual and Multicultural Development*, 6, 467–477.

Grosjean, F. (1988). Exploring the recognition of guest words in bilingual speech. *Language and Cognitive Processes*, 3, 233–274. https://doi.org/10.1080/01690968808402089.

Grosjean, F. (2001). The Bilingual's Language Modes. In J. Nicol (Ed.), *One Mind, Two Languages: Bilingual Language Processing* (pp. 1–25). Oxford: Blackwell.

Grosjean, F. (2013). Speech perception and comprehension. In F. Grosjean & P. Li (Eds.) *The Psycholinguistics of Bilingualism* (pp. 29–49). Oxford: Wiley-Blackwell.

Grüter, T., & Hopp, H. (2021). How permeable are native and non-native syntactic processing to crosslinguistic influence? *Journal of Memory and Language*, 121, 104281. https://doi.org/10.1016/j.jml.2021.104281.

Grüter, T., Lew-Williams, C., & Fernald, A. (2012). Grammatical gender in L2: A production or a real-time processing problem? *Second Language Research*, 28(2), 191–215.

Guasch, M., Boada, R., Ferré, P., & Sánchez-Casas, R. (2013). NIM: A Web-based Swiss Army knife to select stimuli for psycholinguistic studies. *Behavior Research Methods*, 45, 765–771.

Handbook of the International Phonetic Association. (1999). *Cambridge University Press*.

Hebb, D. (1949). *The organization of behavior: A neuropsychological theory*. New York, NY: Wiley.

Hopp, H. (2013). Grammatical gender in adult L2 acquisition: Relations between lexical and syntactic variability. *Second Language Research*, 29(1), 33–56. https://doi.org/10.1177/0267658312461803.

Hopp, H. (2016). Learning (not) to predict: Grammatical gender processing in second language acquisition. *Second Language Research*, 32(2), 277–307. https://doi.org/10.1177/0267658315624960.

Huettig, F., & McQueen, J.M. (2007). The tug of war between phonological, semantic and shape information in language-mediated visual search. *Journal of Memory and Language* (Language-Vision Interaction) 57(4). 460–482. https://doi.org/10.1016/j.jml.2007.02.001.

Hultin, F. (2017). *Phonotactic Structures in Swedish: A Data-Driven Approach*. Retrieved December 8, 2022, from http://urn.kb.se/resolve?urn=urn:nbn:se:su:diva-144259.

Ito, A., Pickering, M.J., & Corley, M. (2018). Investigating the time-course of phonological prediction in native and non-native speakers of English: A visual world eye-tracking study. *Journal of Memory and Language*, 98, 1–11. https://doi.org/10.1016/j.jml.2017.09.002.

Kaan, E. (2014). Predictive sentence processing in L2 and L1: What is different? *Linguistic Approaches to Bilingualism*, 4(2), 257–282. https://doi.org/10.1075/lab.4.2.05kaa.

Keysar, B., Hayakawa, S.L., & An, S.G. (2012). The Foreign-Language Effect: Thinking in a Foreign Tongue Reduces Decision Biases. *Psychological Science*, 23(6), 661–668. https://doi.org/10.1177/0956797611432178.

Kilgarriff, A., Charalabopoulou, F., Gavrilidou, M., Johannessen, J.B., Khalil, S., Kokkinakis, S.J., Lew, R., Sharoff, S., Vadlapudi, R., & Volodina, E. (2014). Corpus-based vocabulary lists for language learners for nine languages. Language Resources and Evaluation, 48:121–163. doi:10.1007/s10579-013-9251-2.

Klimovich-Gray, A., Tyler, L., Randall, B., Kocagoncu, E., Devereux, B., & Marslen-Wilson, W. (2019). Balancing Prediction and Sensory Input in Speech Comprehension: The Spatiotemporal Dynamics of Word Recognition in Context. doi:10.17863/CAM.34013.

Kroll, J.F., & Stewart, E. (1994). Category interference in translation and picture naming: Evidence for asymmetric connections between bilingual memory representations. *Journal of Memory and Language*, 33, 149–174.

Kurnik, M. (2016). Bilingual Lexical Access in Reading : Analyzing the Effect of Semantic Context on Non-Selective Access in Bilingual Memory. Retrieved September 27, 2022, from http://urn.kb.se/resolve?urn=urn:nbn:se:su:diva-129044.

Kuperberg, G.R., & Jaeger, T.F. (2016). What do we mean by prediction in language comprehension? *Language, Cognition and Neuroscience*, 31(1), 32–59. https://doi.org/10.1080/23273798.2015.1102299.

Kuznetsova, A., Brockhoff, P.B., & Christensen, R.H.B. (2020). lmerTest: Tests in linear mixed effects models. R Package Version, 3.1–3. Available: https://cran.r-project.org/web/packages/lmerTest/index.html.

Lagrou, E., Hartsuiker, R.J., & Duyck, W. (2013a). The influence of sentence context and accented speech on lexical access in second-language auditory word recognition. *Bilingualism: Language and Cognition*, 16, 508–517. https://doi.org/10.1017/S1366728912000508.

Lagrou, E., Hartsuiker, R.J., & Duyck, W. (2013b). Interlingual lexical competition in a spoken sentence context: Evidence from the visual world paradigm. *Psychonomic Bulletin & Review*, 20(5), 963–972. https://doi.org/10.3758/s13423-013-0405-4.

Lagrou, E., Hartsuiker, R.J., & Duyck, W. (2015). Do semantic sentence constraint and L2 proficiency influence language selectivity of lexical access in native language listening? *Journal of Experimental Psychology: Human Perception and Performance*, 41, 1524–1538. https://doi.org/10.1037/a0039782.

Lauro, J., & Schwartz, A.I. (2017). Bilingual non-selective lexical access in sentence contexts: A meta-analytic review. *Journal of Memory and Language*, 92, 217–233. https://doi.org/10.1016/j.jml.2016.06.010.

Lemhöfer, K., & Broersma, M. (2012). Introducing LexTALE: a quick and valid Lexical Test for Advanced Learners of English. *Behavior Research Methods*, 44(2), 325–343. https://doi.org/10.3758/s13428-011-0146-0.

Lemhöfer, K., Dijkstra, T., & Michel, M.C. (2004). Three languages, one ECHO: Cognate effects in trilingual word recognition. *Language and Cognitive Processes*, 19(5), 585–611. https://doi.org/10.1080/01690960444000007.

Li, P., & Farkas, I. (2002). 3 A self-organizing connectionist model of bilingual processing. In Roberto R. Heredia & Jeanette Altarriba (eds.), *Advances in Psychology* (Vol. 134, pp. 59–85). North-Holland. https://doi.org/10.1016/S0166-4115(02)80006-1.

Li, P., & MacWhinney, B. (2002). PatPho: A phonological pattern generator for neural networks. *Behavior Research Methods, Instruments & Computers*, 34, 408–415. https://doi.org/10.3758/BF03195469.

Libben, M.R., & Titone, D.A. (2009). Bilingual lexical access in context: Evidence from eye movements during reading. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 35, 381–390. https://doi.org/10.1037/a0014875.

Lijewska, A. (2022). The influence of semantic bias on triple non-identical cognates during reading: Evidence from trilinguals' eye movements. *Second Language Research*. https://doi.org/10.1177/02676583221128525.

Lijewska, A., & Chmiel, A. (2015). Cognate facilitation in sentence context – translation production by interpreting trainees and non-interpreting trilinguals. *International Journal of Multilingualism*, 12(3), 358–375. https://doi.org/10.1080/14790718.2014.959961.

Linck, J.A., & Cunnings, I. (2015). The Utility and Application of Mixed-Effects Models in Second Language Research. *Language Learning*, 65(S1), 185–207. https://doi.org/10.1111/lang.12117.

Lund, K., & Burgess, C. (1996). Producing high-dimensional semantic spaces from lexical co-occurrence. *Behavior Research Methods*, 28(2), 203–208.

Marian, V., Blumenfeld, H.K., & Kaushanskaya, M. (2007). The Language Experience and Proficiency Questionnaire (LEAP-Q): assessing language profiles in bilinguals and multilinguals. *Journal of speech, language, and hearing research: JSLHR*, 50(4), 940–967. https://doi.org/10.1044/1092-4388(2007/067).

Marian, V., & Spivey, M. (2003). Competing activation in bilingual language processing: Within- and between-language competition. *Bilingualism: Language and Cognition*, 6(2), 97–115. https://doi.org/10.1017/S1366728903001068.

Marslen-Wilson, W.D. (1984). Function and process in spoken word recognition: A tutorial review. *Attention and performance: Control of language processes*, 125–150.

Marslen-Wilson, W.D. (1987). Functional parallelism in spoken word-recognition. *Cognition*, 25(1-2), 71–102. doi:10.1016/0010-0277(87)90005-9.

Marslen-Wilson, W.D., & Welsh, A. (1978). Processing interactions and lexical access during word recognition in continuous speech. *Cognitive psychology*, 10(1), 29–63. doi:10.1016/0010- 0285(78)90018-X.

Massaro, D.W. (2001). Speech Perception. In Neil J. Smelser & Paul B. Baltes (eds.), *International Encyclopedia of the Social & Behavioral Sciences*, 14870–14875. Oxford: Pergamon. https://doi.org/10.1016/B0-08-043076-7/01465-0.

McClelland, J.L., & Elman, J.L. (1986). The TRACE model of speech perception. *Cognitive Psycholology*, 18(1), 1–86. doi:10.1016/0010-0285(86)90015-0.

McClelland, J.L., & Rumelhart, D.E. (1981). An interactive activation model of context effects in letter perception: I. An account of basic findings. *Psychological Review*, 88(5), 375–407. doi:10.1037/0033-295X.88.5.375.

McDonald, M., & Kaushanskaya, M. (2020). Factors modulating cross-linguistic co-activation in bilinguals. *Journal of Phonetics*, 81, 100981. https://doi.org/10.1016/j.wocn.2020.100981.

Mercier, J., Pivneva, I., & Titone, D. (2016). The role of prior language context on bilingual spoken word processing: Evidence from the visual world task. *Bilingualism: Language and Cognition*, 19, 376–399. https://doi.org/10.1017/S1366728914000340.

Norris, D. (1994). Shortlist: a connectionist model of continuous speech recognition. *Cognition*, 52(3), 189–234. https://doi.org/10.1016/0010-0277(94)90043-4.

Norris, D., & McQueen, J.M. (2008). Shortlist B: a Bayesian model of continuous speech recognition. *Psychological Review*, 115(2), 357–395. https://doi.org/10.1037/0033-295X.115.2.357.

Pardo, J.S., Jay, I.C., & Krauss, R.M. (2010). Conversational role influences speech imitation. *Attention, Perception, & Psychophysics*, 72(8), 2254–2264. https://doi.org/10.3758/BF03196699.

Pisoni, D.B. (2017). Speech Perception. In *The Handbook of Psycholinguistics*, (pp. 193–212). John Wiley & Sons, Ltd. https://doi.org/10.1002/9781118829516.ch9.

Peirce, J.W., Gray, J.R., Simpson, S., MacAskill, M.R., Höchenberger, R., Sogo, H., Kastman, E., & Lindeløv, J. (2019). PsychoPy2: experiments in behavior made easy. *Behavior Research Methods.* doi:10.3758/s13428-018-01193-y.

R Core Team (2022). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. Retrieved from https://www.R-project.org/.

Rastle, K., McCormick, S.F., Bayliss, L., & Davis, C.J. (2011). Orthography influences the perception and production of speech. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 37(6), 1588–1594.

Ringbom, H. (2007). *Crosslinguistic similarity in foreign language learning*. Clevedon: Multilingual Matters.

Schroeder, S.R., & Marian, V. (2017). Cognitive consequences of trilingualism. *International Journal of Bilingualism*, 21(6), 754–773. https://doi.org/10.1177/1367006916637288.

Schwartz, A.I., & Kroll, J.F. (2006). Bilingual lexical activation in sentence context. *Journal of Memory and Language*, 55(2), 197–212. https://doi.org/10.1016/j.jml.2006.03.004.

Shook, A., Goldrick, M., Engstler, C., & Marian, V. (2015). Bilinguals Show Weaker Lexical Access During Spoken Sentence Comprehension. *Journal of psycholinguistic research*, 44(6), 789–802. https://doi.org/10.1007/s10936-014-9322-6.

Shook, A., & Marian, V. (2013). The Bilingual Language Interaction Network for Comprehension of Speech. *Bilingualism: Language and Cognition*, 16(2), 304–324. https://doi.org/10.1017/S1366728912000466.

Shook, A., & Marian, V. (2019). Covert co-activation of bilinguals' non-target language: Phonological competition from translations. *Linguistic Approaches to Bilingualism*, 9(2), 228–252. https://doi.org/10.1075/lab.17022.sho.

Sigurd, B. (1965). *Phonotactic structures in Swedish* (Unpublished doctoral dissertation). Lund universitet.

Spivey, M.J., & Marian, V. (1999). Cross talk between native and second languages: Partial activation of an irrelevant lexicon. *Psychological Science*, 10(3), 281–284. https://doi.org/10.1111/1467-9280.00151.

Sunderman, G., & Schwartz, A.I. (2008). Using Cognates to Investigate Cross-Language Competition in Second Language Processing. *TESOL Quarterly*, 42(3), 527–536.

Szubko-Sitarek, W. (2011). Cognate facilitation effects in trilingual word recognition. *Studies in Second Language Learning and Teaching*, 1(2), 189–208. https://doi.org/10.14746/ssllt.2011.1.2.2.

Szubko-Sitarek, W. (2015). *Multilingual Lexical Recognition in the Mental Lexicon of Third Language Users*. Berlin, Heidelberg: Springer. https://doi.org/10.1007/978-3-642-32194-8.

Tanenhaus, M.K., Leiman, J.M., & Seidenberg, M.S. (1979). Evidence for multiple stages in the processing of ambiguous words in syntactic contexts. *Journal of Verbal Learning & Verbal Behavior*, 18. 427–440.

Titone, D., Libben, M., Mercier, J., Whitford, V., & Pivneva, I. (2011). Bilingual lexical access during L1 sentence reading: The effects of L2 knowledge, semantic constraint, and L1–L2 intermixing. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 37, 1412–1431. https://doi.org/10.1037/a0024492.

The Leipzig Glossing Rules for interlinear morpheme-by-morpheme glosses (2008). Retrieved from https://www.eva.mpg.de/lingua/resources/glossing-rules.php.

Thierry, G., & Wu, Y.J. (2007). Brain potentials reveal unconscious translation during foreign-language comprehension. *Proceedings of the National Academy of Sciences*, 104(30), 12530–12535. https://doi.org/10.1073/pnas.0609927104.

Tokowicz, N. (2015). *Lexical Processing and Second Language Acquisition*. New York, NY: Routledge.

Van Assche, E., Drieghe, D., Duyck, W., Welvaert, M., & Hartsuiker, R.J. (2011). The influence of semantic constraints on bilingual word recognition during sentence reading. *Journal of Memory and Language*, 64(1), 88–107. https://doi.org/10.1016/j.jml.2010.08.006.

Van Hell, J.G., & de Groot, A.M.B. (2008). Sentence context modulates visual word recognition and translation in bilinguals. *Acta Psychologica*, 128(3), 431–451. https://doi.org/10.1016/j.actpsy.2008.03.010.

Van Hell, J.G., & Dijkstra, T. (2002). Foreign language knowledge can influence native language performance in exclusively native contexts. *Psychonomic Bulletin & Review*, 9(4), 780–789. https://doi.org/10.3758/BF03196335.

Van Heuven, W.J.B., Mandera, P., Keuleers, E., & Brysbaert, M. (2014). Subtlex-UK: A New and Improved Word Frequency Database for British English. *Quarterly Journal of Experimental Psychology*, 67(6), 1176–1190. https://doi.org/10.1080/17470218.2013.850521.

Vallar, G. (2001). Short-term Memory: Psychological and Neural Aspects. In Neil J. Smelser & Paul B. Baltes (eds.), *International Encyclopedia of the Social & Behavioral Sciences*, 14049–14055. Oxford: Pergamon. https://doi.org/10.1016/B0-08-043076-7/03515-4.

Van Orden, G.C. (1987). A ROWS is a ROSE: Spelling, sound, and reading. *Memory & Cognition*, 15, 181–198. https://doi.org/10.3758/BF03197716.

Von Holzen, K., & Mani, N. (2014). Bilinguals implicitly name objects in both their languages: an ERP study. *Frontiers in Psychology*, 5.

Weber, A., & Cutler, A. 2004. Lexical competition in non-native spoken-word recognition. *Journal of Memory and Language*, 50(1), 1–25. https://doi.org/10.1016/S0749-596X(03)00105-0.

Weber, A., & Scharenborg, O. (2012). Models of spoken-word recognition. *WIREs Cognitive Science*, 3(3), 387–401. https://doi.org/10.1002/wcs.1178.

Westergaard, M., Mitrofanova, N., Mykhaylyk, R., & Rodina, Y. (2017). Crosslinguistic influence in the acquisition of a third language: The Linguistic Proximity Model. *International Journal of Bilingualism*, 21(6), 666–682. https://doi.org/10.1177/1367006916648859.

Winter, B. (2019). *Statistics for Linguists: An Introduction Using R*. New York: Routledge. https://doi.org/10.4324/9781315165547.

Witte, E., Edlund, J., Jönsson, A., & Danielsson, H. (2021). Swedish Word Metrics: A Swe-Clarin resource for psycholinguistic research in the Swedish language. *Paper presented at the CLARIN Annual Conference 2021*.

Witte, E., & Köbler, S. (2019). Linguistic Materials and Metrics for the Creation of Well-Controlled Swedish Speech Perception Tests. *Journal of Speech, Language, and Hearing Research*, 62(7), 2280–2294. doi:10.1044/2019_JSLHR-S-18-0454

Wu, Y.J., & Thierry, G. (2010). Chinese–English Bilinguals Reading English Hear Chinese. *Journal of Neuroscience*, 30(22), 7646–7651. https://doi.org/10.1523/JNEUROSCI.1602-10.2010.

Yanushevskaya, I., & Bunčić, D. (2015). Russian. *Journal of the International Phonetic Association*, 45(2), 221–228. https://doi.org/10.1017/S0025100314000395.

Appendix A

Schematised diagrams of the BIA+ and the BLINCS models.

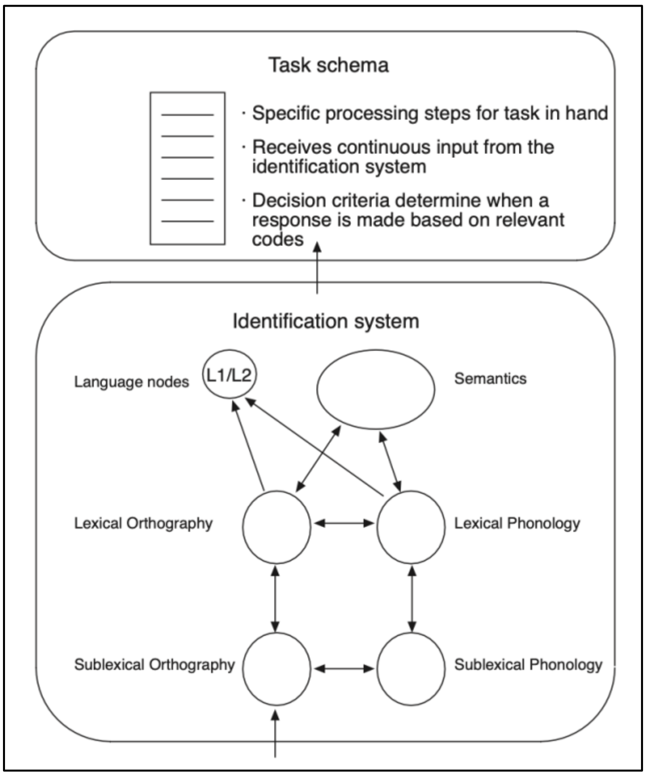

Figure A1. Bilingual Interactive Activation Plus Model of word recognition (adapted from Dijkstra & Van Heuven, 2002: 182).

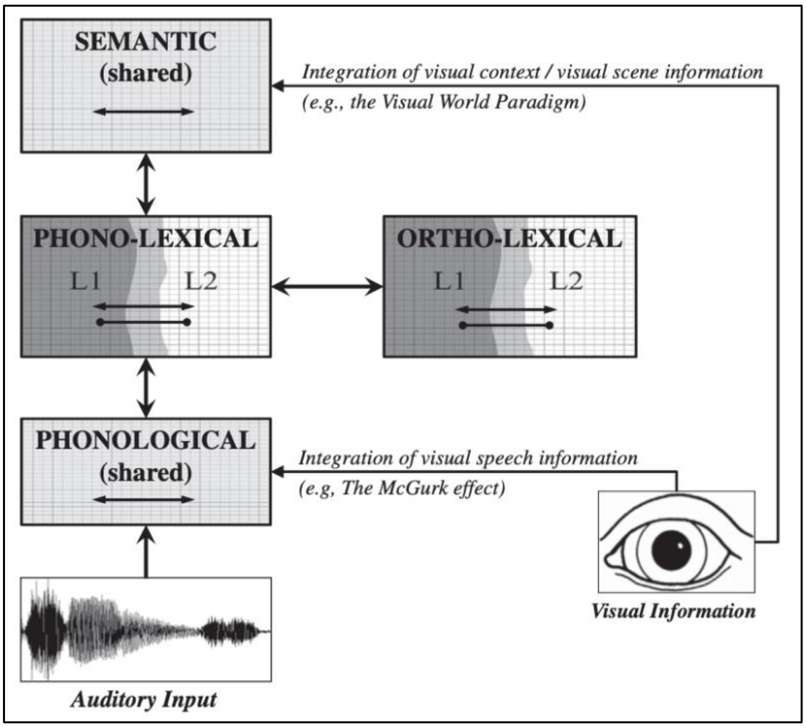

Figure A2. The Bilingual Language Interaction Network for Comprehension of Speech (adapted from Shook & Marian, 2013: 22).

Cohort model

The first psycholinguistic model of spoken word recognition, Cohort (Marslen-Wilson, 1984, 1987; Marslen-Wilson & Welsh, 1978) focuses on the temporal aspect of the process, dividing it into three stages: access, selection, and integration (Weber & Scharenborg, 2012). Acoustic signal mapping occurs during the access stage which co-activates words that match the input in their onset, creating a cohort group. At the following selection stage, those candidates whose next phoneme mismatches the input are continuously excluded from the cohort until the only perfectly matching candidate remains which is then integrated with the syntactic and semantic information of the context. To exemplify, the Swedish word *jordgubbstårta* [²ʝuːɖ̣.gɵbs.tˌoː.ʈa] (strawberry pie) will compete for selection with *jord* [ˈʝuːɖ] (earth) and *jordgubbe* [²ʝuːɖ̣.gˌɵbː.ẹ*]* (strawberry) when a listener hears [ˈʝuːɖ], but at the presentation of /g/, the "*jord*" candidate will be excluded from the cohort.

The last integration stage also includes checking candidate(s) against sentential context constraints, resulting in a possible removal of a candidate if it does not agree with the context demands. The original model cannot, however, account for the word-frequency effect (more frequent words are recognised faster) and listeners' ability to recognise words which mismatch the context or acoustics. These limitations are addressed in the later Cohort II version, which is, unlike the earlier one, based on the bottom-up principles only (Marslen-Wilson, 1987). Cohort II makes it possible for slightly mismatching words to remain in the cohort and introduces the resting activation values to each word depending on their frequency. The biggest caveat of the two versions of the Cohort model is their reliance exclusively on the initial onset of a word while it has been shown empirically that later parts of words also interact, e.g., the rhyming *bear* interacts with *declare* (Shook & Marian, 2013: 8).

TRACE model

The Cohort model was later used as a basis for TRACE (McClelland & Elman, 1986), the first computational model of spoken word recognition which, unlike the later Cohort, assigns more power to the top-down processes. Being a localist connectionist model, TRACE assumes one node – one unit representation spread across three layers of nodes: a feature, a phoneme, and a word (Weber & Scharenborg, 2012). The input fitting nodes get co-activated relative to their similarity, spreading the activation to other layers of representation. This creates a competition, e.g., when hearing "*sun"*, *run* and *under* are also considered (Weber & Scharenborg, 2012: 390), but *sun* gradually inhibits the other items because each candidate's activation is proportionate to its similarity to the input. However, the inhibition only happens within one layer and the word activation remains unchanged when the input mismatches.

The word layer sends feedbacks to other layers, making TRACE an interactive model in which lexical knowledge can alter perception. The originally lacking word frequency account was later introduced by Dahan, Magnuson & Tanenhaus (2001) through a resting-activation level, connection strengths' adjustments or as a post-activation decision bias. According to TRACE, the onset overlap creates an earlier effect than the overlap in rhyme, which has, indeed, been observed (Allopenna et al., 1998). The model, nevertheless, has been criticised for the duplication of the network necessary to recognise words over time and the lexical feedback loop – the model's feedback cannot improve accuracy or speed of processing. Moreover, it assumes that top-down processes can influence the word-activation stage, which has not been observed empirically (Klimovich-Gray et al., 2019).

Shortlist model

In order to address some of the above limitations, the Shortlist model was developed (Norris, 1994). It combines the feed-forward phoneme decision approach of the Cohort model with the competition mechanisms of TRACE. The generation of candidates and the competition processes are separated, thus, within the first stage, a shortlist of up to 30 candidates is created, and the candidates form their own interactive-activation network. The network items then undergo the second stage competition processes, in which less-input-matching items are inhibited, gradually decreasing their activation as the mismatching information is presented. Similar to TRACE, the best-matching candidate inhibits less input-similar ones. Importantly, the whole two-stage process is repeated every time a new phoneme is presented (with a new shortlist every time) and the information from each of these processes only goes in a feed-forward way.

The TRACE's duplication of the whole lexical system at every new phoneme presentation implausibly limited the possible lexicon size the model could work with, but Shortlist has resolved this limitation by introducing two stages of processing. Moreover, Shortlist can account for the lexical stress constraint (observed, e.g., in English, non-stressed vowels are reduced) and a decreased activation of candidates which leave the adjacent input incompatible with a real word in a language (e.g., the activation of *apple* in '*fapple*' is reduced because there cannot be such a word as '*f*' in English) (Weber & Scharenborg, 2012). The later Shortlist B version takes Bayesian principles for the basis, changing word activations to probabilities and word frequencies to prior probabilities, considering mismatches through likelihoods. It is, thus, suited for calculating the efficiency of the word recognition process (Norris & McQueen, 2008).

Cohort, TRACE and Shortlist are monolingual spoken word recognition models which set the stage for the similar bilingual (potentially multilingual) lexicon organisation and language processing models.

Appendix B

Descriptive statistics for participants' background information.

	Mean	*SD*	Range	Comments and clarifications
Age (years)	36.4	9.25	22–60	
Age of acquisition of Swedish	25.03	7.59	8–42	One participant acquired Swedish before the age of 12.
Age of acquisition of English	7.73	3.43	3–19	
Length of residence in Sweden (years)	8.55	7.64	1–30	3 participants have lived in Sweden for ≤ 2.25 years and 1 subject had been living in Spain for three months prior to the experiment but 7 years in Sweden before that.
Length of exposure to Swedish (years)	11.2	9.86	1–48	
Length of residence in an English-speaking country (years)	0.28	0.85	0–5	18 participants considered Sweden to be an English-speaking country, reporting a wide daily English use, however, only the residence in an officially English-speaking country is considered for the study.
Length of residence in a Russian-speaking country (years)	26.64	8.67	8–50	
Use of Swedish (%)	31.9	15.89	5–68	
Use of English (%)	23.2	13.57	0–60	One participant reported not using English currently.
Use of Russian (%)	36.38	20.2	0–80	One participant reported not using Russian currently.
Swedish LexTALE score	76.84	12	55–100	
English LexTALE score	74.1	13.15	52.5–96.3	
Picture naming accuracy score	69.25	17.01	29.9–93.8	
Number of languages	5.05	1.24	3–9	
Bilingual status	8 participants reported being balanced or sequential bilinguals in Russian and Belarusian (n=2), Ukrainian (n=5) and Icelandic (n=1).			
Other foreign languages (number of subjects)	German (17), French (14), Spanish (10), Ukrainian (5), Italian (4), Polish (4), Finnish (3), Norwegian (3), Belarusian (2), Esperanto (2), Latvian (2), Arabic (1), Bulgarian (1), Danish (1), Estonian (1), Hebrew (1), Hungarian (1), Japanese (1), Karelian (1), Latin (1), Rumanian (1), and Swiss-German (1) in the order of frequency.			

Appendix C

Word stimuli with their properties.

In the Type column, TN refers to target nouns, COC – cognate overlap competitors, NOC – noncognate overlap competitors, CNC – cognate non-overlap competitors, and NNC – noncognate non-overlap competitors. PNC and ONC – phonetic and orthographic neighbour count, respectively. MS corresponds to the main stress syllable. OS represents the orthographic similarity count between English and Swedish forms. The properties were obtained from the AFC list (Witte et al., 2021; Witte & Köbler, 2019) and the NIM database (Guasch et al., 2013). The Russian phonological forms are provided following the International Phonetic Alphabet (IPA) transcriptions (/ɫ/ denotes a pharyngealized /l/). For Swedish, "²" and "ˈ" stand for Pitch Accents 2 and 1.

Type	Orthographic form (SWE)	IPA (SWE)	Orthographic form (ENG)	Orthographic form (RUS)	IPA (RUS)	Syllable count	Phone count	Letter count	Zipf Value	PNC	ONC	Tone	MS	OS score
TN	armbåge	² arːmbˌoːgẹ	elbow	локоть	ˈɫokətʲ	3	7	7	3.1359	14	21	1	1	0.23
TN	barn	ˈbɑː ɳ	children	дети	ˈdʲetɪ	1	3	4	5.7136	31	38	1	1	0.09
TN	ben	ˈb eː n	leg	нога	nɐˈga	1	3	3	4.9559	7	9	2	1	0.16
TN	blomma	² blʊmːa	flower	цветок	t͡svʲɪˈtok	2	5	6	4.1375	27	20	1	1	0.08
TN	bock	ˈb ɔ kː	goat	козел	kɐˈzɵ̠ɫ	1	3	4	3.1537	21	30	1	1	0.06
TN	bord	ˈb uː ɖ	table	стол	stoɫ	1	3	4	4.4875	10	10	1	1	0.15
TN	brev	ˈb r eː v	letter	письмо	pʲɪsʲˈmo	1	4	4	4.4889	13	10	2	1	0.08
TN	bricka	² b r ɪ kːa	tray	поднос	pɐˈdnos	2	5	6	3.5752	5	7	1	1	0.14
TN	golv	ˈg ɔ lː v	floor	пол	poɫ	1	4	4	4.1761	15	33	1	1	0.04
TN	gran	ˈg r ɑː n	fir-tree	ёлка	ˈjɵɫkə	1	4	4	4.0983	6	8	2	1	0.22
TN	groda	² g r uː da	frog	лягушка	lʲɪˈguʂkə	2	5	5	3.4436	1	2	1	2	0.07
TN	kalkon	k a lˈ k uːn	turkey	индейка	ɪnʲˈdʲejkə	2	6	6	3.6122	1	4	1	2	0.04
TN	kavaj	k a ˈva jː	suit	пиджак	pʲɪd͡ʐˈʐak	2	5	5	4.2897	3	4	1	2	0.03
TN	kontakt	k ɔ nˈt a kːt	plug	вилка	viɫkə	2	7	7	4.6828	4	4	1	1	0.13
TN	koppel	ˈk ɔ pː ẹ l	leash	поводок	pəvɐˈdək	2	5	6	3.5728	15	12	2	1	0.20
TN	kratta	² k r a tː a	rake	грабли	ˈgrabɫɪ	2	5	6	3.4508	10	11	2	1	0.03
TN	kruka	² k r ʉː ka	pot	горшок	gɐrˈʂok	2	5	5	3.7508	21	33	2	1	0.07
TN	kula	² k ʉː . l a	marble	шарик	ʂarʲɪk	2	4	4	3.5794	22	21	2	1	0.07
TN	låda	² l oː d a	drawer	ящик	ˈjæɕːɪk	2	4	4	4.1748	21	23	2	1	0.08
TN	låga	² l oː g a	flame	пламя	ˈpɫamʲə	2	4	4	4.2708	1	1	2	1	0.05
TN	lastbil	² l a sːtbˌiːl	truck	грузовик	grʊzɐˈvʲik	2	7	7	3.6269	1	1	2	1	0.03
TN	leksak	² l eː k.sˌɑː k	toy	игрушка	ɪˈgruʂkə	2	6	6	3.8298	24	23	1	1	0.25
TN	mål	ˈm oː l	goal	ворота	vɐˈrotə	1	3	3	5.1276	19	24	1	1	0.08
TN	mask	ˈm a sː k	worm	червяк	t͡ɕɪrˈvʲak	1	4	4	3.9057	4	11	1	1	0.15
TN	moln	ˈm oː l n	cloud	облако	ˈobɫəkə	1	4	4	4.1958	20	17	2	1	0.05
TN	nalle	² n a lː ẹ	teddy-bear	мишка	mʲɪˈʂkə	2	4	5	3.7832	1	1	1	3	0.08
TN	paraply	p a r a ˈp lyː	umbrella	зонт	zont	3	7	7	3.6545	20	14	1	1	0.13
TN	peng	ˈp ɛ̠ ŋː	money	деньги	ˈdʲenʲgɪ	1	3	4	3.6498	4	4	2	1	0.06
TN	pensel	² p ɛ̠ nː s ẹ l	brush	кисть	kʲisʲtʲ	2	6	6	3.6537	13	18	2	1	0.16
TN	piska	² p ɪ sː k a	whip	кнут	ˈknʊt	2	5	5	3.2562	2	5	2	1	0.06
TN	pojke	² p ɔ jː k ẹ	boy	мальчик	ˈmalʲt͡ɕɪk	2	5	5	4.4233	1	1	2	1	0.13
TN	resväska	² reːsvˌɛ̠ sːka	suitcase	чемодан	t͡ɕɪmɐˈdan	3	8	8	3.6928	27	20	1	1	0.18
TN	rock	ˈr ɔ kː	coat	пальто	pɐlʲˈto	1	3	4	4.3549	0	0	1	3	0.18
TN	servitris	s ẹ r vɪ ˈtr iːs	waitress	официантка	ɐfʲɪt͡sɨˈantkə	3	9	9	3.054	4	7	1	1	0.09
TN	skräp	ˈs k r ɛː p	trash	мусор	ˈmusər	1	5	5	4.0376	10	16	1	1	0.08
TN	spik	ˈs p iː k	nail	гвоздь	gvosʲtʲ	1	4	4	3.3568	7	16	1	1	0.08
TN	stig	ˈs t iː g	path	дорожка	dɐˈroʂkə	1	4	4	3.8758	7	9	1	1	0.04
TN	strut	ˈs t r ʉː t	cone	рожок	rəˈʐok	1	5	5	3.0425	4	20	1	1	0.06
TN	svans	ˈs v ɑː n s	tail	хвост	xvost	1	5	5	3.5824	5	5	2	1	0.13
TN	tändare	² t ɛ̠ nː d arẹ	lighter	зажигалка	zəʐɨˈgaɫkə	3	7	7	3.0468	7	7	2	1	0.06
TN	tavla	² t ɑː v l a	painting	картина	kɐrˈtʲinə	2	5	5	4.0893	9	9	2	1	0.30

TN	trumma	² t r ɵ m: a	drum	барабан	bərɐˈban	2	5	6	2.9765	4	4	2	1	0.06
TN	uggla	² ɵ g: l a	owl	сова	sɐˈva	2	4	5	3.6001	12	16	1	1	0.05
TN	valp	ˈv a l: p	puppy	щенок	ɕːɪˈnok	1	4	4	3.7725	14	13	2	1	0.06
TN	väska	² v ɛ̝ s: k a	bag	сумка	ˈsumkə	2	5	5	4.7823	5	14	2	1	0.24
TN	växt	ˈ v ɛ̝ k: s t	plant	растение	rɐˈsʲtʲenʲɪjə	1	5	4	4.2634	0	0	2	1	0.12
TN	växthus	² v ɛ̝ k:sthˌʉ:s	greenhouse	теплица	tʲɪˈplʲit͡sə	2	8	7	3.2436	1	1	2	1	0.05
TN	verktyg	² v ɛ̝ r:ktˌy: g	tools	инструменты	ɪnstrʊˈmʲentɪ	2	7	7	4.1499	14	21	1	1	0.23
COC	badkar	² b ɑ:d kˌɑ: r	bathtub	ванна	ˈvan:ə	2	6	6	3.7693	1	8	2	1	0.38
COC	bält	² b ɛ̝ l: t ẹ	belt	ремень	rʲɪˈmʲenʲ	2	5	5	3.7481	9	9	2	1	0.52
COC	bänk	ˈb ɛ̝ ŋ: k	bench	скамейка	skɐˈmʲeɪjkə	1	4	4	3.9686	12	10	1	1	0.35
COC	båt	ˈb o: t	boat	лодка	ˈłotkə	1	3	3	4.2542	24	24	1	1	0.56
COC	bro	ˈb r u:	bridge	мост	most	1	3	3	3.6743	16	27	1	1	0.44
COC	bröst	ˈb r ø̣ s: t	breast	грудь	grutʲ	1	5	5	4.5001	8	11	1	1	0.73
COC	cirkel	² s ɪ r: k ẹ l	circle	круг	kruk	2	6	6	3.6365	3	2	2	1	0.61
COC	cykel	ˈs y: . k ẹ l	bicycle	велосипед	vʲɪłəsʲɪˈpʲet	2	5	5	4.3963	2	2	1	1	0.39
COC	dansare	² d a n: s a r ẹ	dancer	танцор	ˈtanˈt͡sor	3	7	7	3.3985	3	4	2	1	0.58
COC	droppe	² d r ɔ p: ẹ	drop	капля	ˈkaplʲə	2	5	6	3.5215	3	7	2	1	0.70
COC	finger	ˈf ɪ ŋ: ẹ r	finger	палец	ˈpalʲɪt͡s	2	5	6	3.9909	12	13	1	1	1.00
COC	fjäder	ˈ f ʝ ɛ: d ẹ r	feather	перо	pʲɪˈro	2	6	6	3.3141	4	5	1	1	0.60
COC	fot	ˈf u: t	foot	ступня	stʊˈpnʲa	1	3	3	4.2851	16	28	1	1	0.82
COC	glas	ˈg l ɑ: s	glass	стакан	stɐˈkan	1	4	4	4.8352	12	26	1	1	0.86
COC	hammare	ˈ h a m: a r ẹ	hammer	молоток	məłɐˈtok	3	6	7	3.2127	5	5	2	1	0.73
COC	häst	ˈh ɛ̝ s: t	horse	лошадь	ˈłoʂətʲ	1	4	4	4.8928	20	17	1	1	0.35
COC	helikopter	hẹlɪ ˈ kɔp:tẹr	helicopter	вертолет	vʲɪrtɐˈlʲɵt	4	10	10	3.3578	1	1	1	3	0.90
COC	hjärta	²ʝ ɛ̝ ʈ: a	heart	сердце	ˈsʲert͡sə	2	4	6	4.8484	16	6	2	1	0.48
COC	horn	ˈh u: ɳ	horn	рог	rok	1	3	4	3.5811	17	13	1	1	1.00
COC	huvud	² h ʉ: v ɵ d	head	голова	gəłɐˈva	2	5	5	4.7227	2	4	2	1	0.55
COC	jacka	² ʝ a k: a	jacket	куртка	ˈkurtkə	2	4	5	4.6564	22	18	2	1	0.65
COC	kamel	k a ˈ m e: l	camel	верблюд	vʲɪrˈblʲut	2	5	5	3.0686	6	10	1	2	0.61
COC	kol	ˈk o: l	coal	уголь	ˈugəlʲ	1	3	3	3.644	24	39	1	1	0.28
COC	läppstift	² l ɛ̝ p:stˌɪ f: t	lipstick	помада	pəˈmadə	2	8	9	4.1423	1	1	2	1	0.53
COC	lista	² l ɪ s: t a	list	список	spˈɪsək	2	5	5	4.7056	18	23	2	1	0.75
COC	mugg	ˈm ɵ g:	mug	кружка	ˈkruʂkə	1	3	4	3.7531	20	10	1	1	0.92
COC	nyckelring	² n ʏk:.ẹl.rˌɪŋ:	keyring	брелок	brɪˈłok	3	8	10	3.017	1	1	2	1	0.52
COC	olja	² ɔ l: ʝ a	oil	масло	ˈmasłə	2	4	4	4.4833	8	10	2	1	0.39
COC	pannkaka	² p aŋ:.kˌɑ:.ka	pancake	блины	blɪˈnɨ	3	7	8	3.7326	2	2	2	1	0.60
COC	papper	² p a p: ẹ r	paper	бумага	bʊˈmagə	2	5	6	4.6322	3	7	2	1	0.94
COC	päron	² p æ:. r ɔ n	pear	груша	ˈgruʂə	2	5	5	3.95	1	3	2	1	0.36
COC	pipa	² p i: p a	pipe	трубка	ˈtrupkə	2	4	4	3.3234	14	19	2	1	0.71
COC	präst	ˈp r ɛ̝ s: t	priest	священник	svʲɪˈɕ:enʲ:ɪk	1	5	5	3.5478	7	4	1	1	0.73
COC	pump	ˈp ɵ m: p	pump	насос	nɐˈsos	1	4	4	3.6981	7	9	1	1	1.00
COC	rakhyvel	² r ɑ:khˌy:vẹl	razor	бритва	ˈbritvə	3	8	8	3.0201	1	1	2	1	0.41
COC	rep	ˈr e: p	rope	верёвка	vʲɪˈrʲɵfkə	1	3	3	3.7981	11	19	1	1	0.49
COC	ring	ˈr ɪ ŋ:	ring	кольца	ˈkolʲt͡sə	1	3	4	4.5016	27	28	1	1	1.00
COC	rot	ˈr u: t	root	корень	ˈkorʲɪnʲ	1	3	3	3.1941	23	35	1	1	0.92
COC	såg	ˈs o: g	saw	пила	pʲɪˈła	1	3	3	5.6101	22	23	1	1	0.38
COC	sandlåda	² s a n:dlˌo:da	sandbox	песочница	pʲɪˈsot͡ɕnɪt͡sə	3	8	8	3.1323	2	2	2	1	0.55
COC	sten	ˈs t e: n	stone	камень	ˈkamʲɪnʲ	1	4	4	4.3615	9	32	1	1	0.58
COC	svala	² s v ɑ: l a	swallow	ласточка	ˈłastət͡ɕkə	2	5	5	3.4161	14	23	2	1	0.46
COC	svan	ˈs v ɑ: n	swan	лебедь	ˈlʲebʲɪtʲ	1	4	4	3.0972	9	23	1	1	0.72
COC	torn	ˈt u: ɳ	tower	башня	ˈbaʂnʲə	1	3	4	3.404	13	30	1	1	0.49
COC	underkläder	²ɵn:dẹrklˌɛ:dẹr	underwear	белье	bʲełˈjɵ	4	11	11	4.1879	1	1	2	1	0.73
COC	vagn	ˈv a ŋ: n	wagon	тележка	tʲɪˈlʲeʐkə	1	4	4	4.3293	5	10	1	1	0.40
COC	vattenmelon	²vat:ẹnmẹlˌu:n	watermelon	арбуз	ɐrˈbus	4	10	11	3.5909	1	1	2	1	0.56
COC	vinglas	² v ɪ ŋ: l a s	wineglass	бокал	bəˈkal	2	6	7	3.35	11	8	2	1	0.51
NOC	berg	ˈb ɛ̝ r: ʝ	mountain	гора	ˈgorɨ	1	4	4	4.2517	7	15	1	1	0.02
NOC	blixt	ˈb l ɪ k: s t	lightning	молния	ˈmołnʲɪjə	1	6	5	3.9051	1	3	1	1	0.13
NOC	brunn	ˈb r ɵ n:	well	колодец	kɐˈłodʲɪt͡s	1	4	5	3.094	8	16	1	1	0.04
NOC	ekorre	² ɛ̝ k: ɔ r ẹ	squirrel	белка	ˈbʲełkə	3	5	6	3.1763	2	2	2	1	0.25

NOC	element	ȩ l ȩ ˈm ɛ̯ n: t	radiator	батарея	bətɐˈrʲejə	3	7	7	3.7175	1	2	1	3	0.06
NOC	eluttag	² e: l.ʉ . t ˌ ɑ: g	socket	розетка	rɐˈzʲetkə	3	6	7	2.9915	0	0	2	1	0.00
NOC	fälla	² f ɛ̯ l: a	trap	капкан	kɐpˈkan	2	4	5	3.9244	21	18	2	1	0.06
NOC	färg	ˈf ɛ̯ r: ʝ	paint	краска	ˈkraskə	1	4	4	5.1186	7	8	1	1	0.04
NOC	ficka	² f ɪ k: a	pocket	карман	kɐrˈman	2	4	5	3.4938	17	15	2	1	0.17
NOC	fiol	f ɪ ˈ u: l	violin	скрипка	ˈskrʲipkə	2	4	4	3.1687	1	3	1	2	0.29
NOC	frisör	f r ɪ ˈs ø: r	hairdresser	парикмахер	pərʲɪkˈmaxʲɪr	2	6	6	4.1907	2	4	1	2	0.23
NOC	gren	ˈg r e: n	branch	ветка	ˈvʲetkə	1	4	4	3.6225	11	30	1	1	0.07
NOC	halsband	² h al:sbˌa n: d	necklace	бусы	bˈusɨ	2	8	8	4.5581	2	2	2	1	0.11
NOC	handflata	² h a n: dfl ˌɑ:ta	palm	ладонь	łɐˈdonʲ	3	9	9	2.6456	2	2	2	1	0.10
NOC	handske	² h a n: d . s k ȩ	glove	перчатка	pʲɪrˈt͡ɕatkɪ	2	7	7	2.8389	1	1	2	1	0.23
NOC	häxa	² h ɛ̯ k: s a	witch	ведьма	ˈvʲedʲmə	2	5	4	3.2263	11	6	2	1	0.06
NOC	hink	ˈh ɪ ŋ: k	bucket	ведро	vʲɪˈdro	1	4	4	3.551	11	20	1	1	0.05
NOC	hjärna	² ʝ ɛ: ɳ a	brain	мозг	mosk	2	4	6	4.3085	16	7	2	1	0.10
NOC	hjul	ˈʝ ʉ: l	wheel	колесо	kəlʲɪˈso	1	3	4	3.9148	20	4	1	1	0.25
NOC	hörlur	² h ø: . ɭ ˌ ʉ: r	earphone	наушник	nɐˈuʂnʲɪkʲɪ	2	5	6	2.0454	1	1	2	1	0.06
NOC	hörn	ˈh ø: ɳ	corner	угол	ˈugəł	1	3	4	4.1698	14	14	1	1	0.17
NOC	hylla	² h ʏ l: a	shelf	полка	ˈpołkə	2	4	5	4.1208	15	14	2	1	0.09
NOC	jordnöt	² ʝ u: ɖ . ɳ ˌ ø: t	peanut	арахис	ɐrˈaxʲɪs	2	6	7	2.1537	0	0	2	1	0.25
NOC	käpp	ˈɕ ɛ̯ p:	cane	трость	trostʲ	1	3	4	2.9618	15	8	1	1	0.05
NOC	kista	ˈɕ i: s t a	coffin	гроб	grop	2	5	5	3.6305	1	15	1	1	0.06
NOC	ljus	ˈʝ ʉ: s	candle	свеча	svʲɪˈt͡ɕa	1	3	4	4.9568	33	15	1	1	0.05
NOC	midja	² m i: d . ʝ a	waist	талия	ˈtalʲɪjə	2	5	5	3.7484	3	6	2	1	0.09
NOC	mur	ˈm ʉ: r	wall	стена	sʲtʲɪˈna	1	3	3	3.3891	24	33	1	1	0.04
NOC	näve	² n ɛ: v ȩ	fist	кулак	kʊˈłak	2	4	4	3.6394	8	7	2	1	0.05
NOC	ögonbryn	² ø: gɔmbrˌy: n	eyebrow	бровь	brofʲ	3	8	8	4.0013	1	1	2	1	0.15
NOC	ögonfrans	²ø:.gɔɱ.frˌan:s	eyelash	ресница	rʲɪˈsnit͡sɨ	3	9	9	2.4604	0	0	2	1	0.06
NOC	öl	ˈø: l	beer	пиво	ˈpʲivə	1	2	2	4.7092	21	29	1	1	0.02
NOC	örhänge	² ø: r .hˌ ɛ̯ ŋ: . ȩ	earring	серьги	ˈsʲerʲˈgɪ	3	6	7	3.2758	4	4	2	1	0.17
NOC	panna	² p a n: a	forehead	лоб	łop	2	4	5	3.8117	24	20	2	1	0.04
NOC	pil	ˈp i: l	arrow	стрела	strʲɪˈła	1	3	3	3.2007	24	30	1	1	0.03
NOC	rygg	ˈr ʏ g:	back	спина	spʲɪˈna	1	3	4	4.5987	13	9	1	1	0.05
NOC	sjukhus	² ɧ ʉ: k h ˌ ʉ: s	hospital	больница	bɐlʲˈnʲit͡sə	2	6	7	4.2493	0	0	2	1	0.07
NOC	sked	ˈɧ e: d	spoon	ложка	ˈłoʂkə	1	3	4	3.7471	18	15	1	1	0.31
NOC	skinka	² ɧ ɪ ŋ: k a	ham	ветчина	vʲɪt͡ɕ:ɪˈna	2	5	6	4.1272	13	10	2	1	0.05
NOC	skog	ˈs k u: g	forest	лес	lʲes	1	4	4	4.014	11	16	1	1	0.07
NOC	skugga	² s k ɵ g: a	shadow	тень	tʲenʲ	2	5	6	4.0533	14	10	2	1	0.35
NOC	smör	ˈs m ø: r	butter	масло	ˈmasłə	1	4	4	4.7667	7	9	1	1	0.23
NOC	stock	ˈs t ɔ k:	log	бревно	brʲɪvˈno	1	4	5	4.0009	17	13	1	1	0.06
NOC	svamp	ˈs v a m: p	mushroom	гриб	grʲip	1	5	5	4.0763	2	3	1	1	0.06
NOC	sylt	ˈs ʏ l: t	jam	варенье	vɐˈrʲenʲjə	1	4	4	3.7963	11	11	1	1	0.04
NOC	tak	ˈt ɑ: k	roof	крыша	ˈkrɨʂə	1	3	3	4.2073	16	26	1	1	0.04
NOC	tefat	² t e: . f ˌ ɑ: t	saucer	блюдце	ˈblʲut͡s:ə	2	5	5	2.8235	1	2	2	1	0.08
NOC	tupp	ˈt ɵ p:	cock	петух	pʲɪˈtux	1	3	4	3.262	19	11	1	1	0.04
CNC	ägg	ˈɛ̯ g:	egg	яйцо	jɪjˈt͡so	1	2	3	4.8542	21	15	1	1	0.55
CNC	arm	ˈa r: m	arm	рука	rʊˈka	1	3	3	4.1798	18	34	1	1	1.00
CNC	ballong	b a ˈl ɔ ŋ:	balloon	шарик	ˈʂarʲɪk	2	5	7	3.4357	4	1	1	2	0.72
CNC	bi	ˈb i:	bee	пчела	pt͡ɕɪˈła	1	2	2	3.502	27	41	1	1	0.33
CNC	bok	ˈb u: k	book	книга	ˈknʲigə	1	3	3	5.204	27	41	1	1	0.82
CNC	boll	ˈb ɔ l:	ball	мяч	mʲæt͡ɕ	1	3	4	4.1674	28	18	1	1	0.74
CNC	bröd	ˈb r ø: d	bread	хлеб	xlʲep	1	4	4	4.6507	9	13	1	1	0.67
CNC	buske	² b ɵ s: k ȩ	bush	куст	kust	2	5	5	3.3027	5	7	2	1	0.61
CNC	elefant	ȩ l ȩ ˈf a n: t	elephant	слон	słon	3	7	7	3.5215	2	2	1	3	0.83
CNC	fisk	ˈf ɪ s: k	fish	рыба	ˈrɨbə	1	4	4	4.4981	8	15	1	1	0.66
CNC	fluga	² f l ʉ: . g a	fly	муха	ˈmuxə	2	5	5	3.5215	8	8	2	1	0.51
CNC	gräs	ˈg r ɛ: s	grass	трава	trɐˈva	1	4	4	4.0328	15	21	1	1	0.63
CNC	hål	ˈh o: l	hole	дыра	dɨˈra	1	3	3	4.5389	24	22	1	1	0.37
CNC	hår	ˈh o: r	hair	волосы	ˈvołəsɨ	1	3	3	5.238	28	30	1	1	0.56
CNC	hårborste	² h o: r.bˌɔ ʂ:.ʈȩ	hairbrush	расческа	rɐɕˈt͡ɕɵskə	3	8	9	3.0231	1	1	1	2	0.42

CNC	honung	² h oː n ɵ ŋ	honey	мёд	mʲɵt	2	5	6	4.2177	2	3	2	1	0.55
CNC	hov	ˈh oː v	hoof	копыто	kɐˈpɨtə	1	3	3	2.9774	19	25	1	1	0.48
CNC	hus	ˈh ʉː s	house	дом	dom	1	3	3	5.0165	26	32	1	1	0.50
CNC	kanon	k a ˈn uː n	canon	пушка	ˈpuʂkə	2	5	5	4.288	5	10	1	2	0.65
CNC	klocka	² k l ɔ kː a	clock	часы	t͡ɕɪˈsɨ	2	5	6	4.3642	17	16	2	1	0.39
CNC	kork	ˈk ɔ rː k	cork	пробка	ˈpropkə	1	4	4	2.9007	10	21	1	1	0.57
CNC	läpp	ˈl ɛ̝ pː	lips	губы	ˈgubɨ	1	3	4	3.309	24	9	1	1	0.58
CNC	lås	ˈl oː s	lock	замок	zɐˈmok	1	3	3	3.6511	35	31	1	1	0.35
CNC	måne	² m oː n ə̝	moon	луна	łʊˈna	2	4	4	3.1837	4	9	2	1	0.35
CNC	mustasch	m ɵ s ˈt ɑː ʂ	moustache	усы	ʊˈsɨ	2	6	8	3.3908	1	1	1	2	0.61
CNC	nät	ˈn ɛː t	net	сетка	ˈsʲetkə	1	3	3	3.7465	19	22	1	1	0.61
CNC	nudel	ˈn ʉː . d ə̝ l	noodle	лапша	łɐpˈʂa	2	5	5	2.0596	3	3	1	1	0.60
CNC	penna	² p ɛ̝ nː a	pen	ручка	ˈrut͡ɕkə	2	4	5	3.8646	14	11	2	1	0.67
CNC	potatis	p ʊ ˈt ɑː t ɪ s	potato	картошка	kɐrˈtoʂkə	3	7	7	4.5813	1	0	1	2	0.69
CNC	pumpa	² p ɵ mː p a	pumpkin	тыква	ˈtɨkvə	2	5	5	3.8054	14	18	2	1	0.61
CNC	regn	ˈr ɛ̝ ŋː n	rain	дождь	doɕːtʲ	1	4	4	4.6244	5	9	1	1	0.56
CNC	säck	ˈs ɛ̝ kː	sack	мешок	mʲɪˈʂok	1	3	4	3.4471	34	22	1	1	0.72
CNC	säl	ˈs ɛː l	seal	тюлень	tʲʉˈlʲenʲ	1	3	3	3.3306	21	25	1	1	0.56
CNC	sångerska	² s ɔ ŋː . ə̝ .ʂk a	singer	певица	pʲɪˈvʲit͡sə	3	7	9	3.3287	2	2	2	1	0.56
CNC	skalle	² s k a lː ə̝	skull	череп	ˈt͡ɕerʲɪp	2	5	6	3.579	5	9	2	1	0.59
CNC	skepp	ˈɧ ɛ̝ pː	ship	корабль	kɐˈrablʲ	1	3	5	3.4514	17	4	1	1	0.55
CNC	skida	² ɧ iː . d a	ski	лыжы	ˈłɨʐɨ	2	4	5	2.4821	17	20	2	1	0.67
CNC	skjorta	² ɧ ʊ ʈː a	shirt	рубашка	rʊˈbaʂkə	2	4	7	4.3695	6	2	2	1	0.44
CNC	snigel	² s n iː g ə̝ l	snail	улитка	ʊˈlʲitkə	2	6	6	3.2234	2	3	2	1	0.66
CNC	spindel	² s p ɪ nː d ə̝ l	spider	паук	pɐˈuk	2	7	7	3.5035	2	2	2	1	0.61
CNC	stjärna	² ɧ ɛː ɳ a	star	звезда	zvʲɪˈzda	2	4	7	4.1491	13	7	2	1	0.47
CNC	svärd	ˈs v ɛː ɖ	sword	меч	mʲet͡ɕ	1	4	5	3.3845	4	8	1	1	0.66
CNC	tält	ˈt ɛ̝ lː t	tent	палатка	pɐˈłatkə	1	4	4	3.8218	18	14	1	1	0.56
CNC	tår	ˈt oː r	tear	слеза	slʲɪˈza	1	3	3	4.0496	33	33	1	1	0.56
CNC	träd	ˈt r ɛː d	tree	дерево	ˈdʲerʲɪvə	1	4	4	4.3251	10	13	1	1	0.47
CNC	tunga	² t ɵ ŋː a	tongue	язык	jɪˈzɨk	2	4	5	4.414	24	16	2	1	0.47
CNC	väst	ˈv ɛː s t	vest	жилет	ʐɨˈlʲet	1	4	4	4.1633	11	27	1	1	0.72
CNC	vinge	² v ɪ ŋː . ə̝	wing	крыло	krɨˈło	2	4	5	3.2381	17	17	2	1	0.33
NNC	and	ˈa nː d	duck	утка	ˈutkə	1	3	3	5.7974	13	29	1	1	0.07
NNC	ärta	² ɛ̝ ʈː . a	pea	горох	gɐˈrox	2	3	4	2.7683	16	17	2	1	0.04
NNC	axel	ˈa kː s ə̝ l	shoulder	плечо	plʲɪˈt͡ɕɵ	2	5	4	4.3075	7	10	1	1	0.06
NNC	bil	ˈb iː l	car	машина	mɐˈʂɨnə	1	3	3	5.0117	22	33	1	1	0.05
NNC	borg	ˈb ɔ rː ʝ	castle	замок	ˈzamək	1	4	4	4.1817	8	20	1	1	0.03
NNC	däck	ˈd ɛ̝ kː	tyre	шина	ˈʂɨnə	1	3	4	3.8744	25	14	1	1	0.05
NNC	domare	² d ʊ mː a r ə̝	judge	судья	sʊˈdʲja	3	6	6	3.9124	6	6	2	1	0.26
NNC	fågel	ˈf oː g ə̝ l	bird	птица	ˈptʲit͡sə	2	5	5	3.9203	2	4	1	1	0.04
NNC	fängelse	² f ɛ̝ ŋː ə̝ l s ə̝	prison	тюрьма	tʲʉrʲˈma	3	7	8	4.234	3	3	2	1	0.07
NNC	får	ˈf oː r	sheep	овца	ɐfˈt͡sa	1	3	3	6.346	25	28	1	1	0.03
NNC	fåtölj	f ɔ ˈt ø̝ lː ʝ	armchair	кресло	ˈkrʲesłə	2	6	6	3.5505	1	1	1	2	0.04
NNC	flygplan	² f l yː g p l ˌɑːn	airplane	самолет	sɐməˈlʲɵt	2	8	8	3.9388	1	1	2	1	0.28
NNC	fönster	ˈf ø̝ nː s t ə̝ r	window	окно	ɐˈkno	2	7	7	4.4837	2	3	1	1	0.06
NNC	fyr	ˈf yː r	lighthouse	маяк	mɐˈjak	1	3	3	3.0231	18	22	1	1	0.01
NNC	glass	ˈg l a sː	icecream	мороженое	mɐˈroʐɨnəɪ̯ə	1	4	5	4.8318	7	12	1	1	0.04
NNC	gunga	² g ɵ ŋː a	swing	качели	kɐˈt͡ɕelʲɪ	2	4	5	3.7477	20	16	2	1	0.19
NNC	haj	ˈh a ʝː	shark	акула	ɐˈkułə	1	3	3	3.3855	29	31	1	1	0.21
NNC	handduk	² h a nː d ˌ ʉː k	towel	полотенце	pəłɐˈtʲent͡sə	2	6	7	3.8072	1	1	2	1	0.07
NNC	hund	ˈh ɵ nː d	dog	собака	sɐˈbakə	1	4	4	4.8428	13	13	1	1	0.07
NNC	igelkott	² iː g ə̝ l k ˌ ɔ tː	hedgehog	еж	ˈjɵʂ	3	7	8	2.9948	1	1	2	1	0.16
NNC	jordgubbe	² ʝ uː ɖ gˌɵ bː ə̝	strawberry	клубника	kłʊbˈnʲikə	3	7	9	3.0874	2	3	2	1	0.12
NNC	kedja	² ɕ eː d ʝ a	chain	цепь	t͡sɛpʲ	2	5	5	3.6674	4	5	2	1	0.07
NNC	klänning	² k l ɛ̝ nː ɪ ŋ	dress	платье	ˈpłatʲɪjə	2	6	8	4.9585	4	6	2	1	0.03
NNC	knapp	ˈk n a pː	button	пуговица	ˈpugəvʲɪt͡sə	1	4	5	3.9779	11	13	1	1	0.06
NNC	kvinna	² k v ɪ nː a	woman	женщина	ˈʐɛnʲɕːɪnə	2	5	6	4.8833	7	8	2	1	0.13
NNC	kylskåp	² ɕ yː l s kˌoːp	fridge	холодильник	xəłɐˈdʲilʲnʲɪk	2	7	7	3.8317	1	1	2	1	0.04

NNC	kyrka	² ɕ ʏ rː k a	church	церковь	ˈt͡sɛrkəfʲ	2	5	5	4.0745	5	7	2	1	0.06
NNC	mössa	² m ø̞ sː a	hat	шапка	ˈʂapkə	2	4	5	4.3608	10	8	2	1	0.06
NNC	napp	ˈn a pː	percifier	соска	ˈsoskə	1	3	4	3.9272	19	14	1	1	0.03
NNC	orm	ˈʊ rː m	snake	змея	zmʲɪˈja	1	3	3	3.4673	3	22	1	1	0.03
NNC	ost	ˈʊ sː t	cheese	сыр	sɨr	1	3	3	4.5584	5	18	1	1	0.04
NNC	plånbok	² p l oːmbˌuː k	wallet	кошелек	kəʂɨˈlʲɵk	2	7	7	4.0488	1	1	2	1	0.06
NNC	räv	ˈr ɛː v	fox	лиса	lʲɪˈsa	1	3	3	3.4201	15	19	1	1	0.05
NNC	rök	ˈr øː k	smoke	дым	dɨm	1	3	3	3.8686	28	28	1	1	0.06
NNC	säng	ˈs ɛ̞ ŋː	bed	кровать	krɐˈvatʲ	1	3	4	4.9951	28	18	1	1	0.04
NNC	skål	ˈs k oː l	bowl	чашка	ˈt͡ɕaʂkə	1	4	4	4.3958	10	12	1	1	0.26
NNC	skåp	ˈs k oː p	cupboard	шкаф	ˈʂkaf	1	4	4	4.002	6	6	1	1	0.04
NNC	sköldpadda	² ɧ ø̞ lːdpˌa dː a	turtle	черепаха	t͡ɕɪrʲɪˈpaxə	3	8	10	2.9653	2	4	2	1	0.04
NNC	slips	ˈs l iː p s	tie	галстук	ˈgałstʊk	1	5	5	3.4331	4	10	1	1	0.06
NNC	spegel	² s p eː g ə̞ l	mirror	зеркало	ˈzʲerkəłə	2	6	6	4.0063	4	5	2	1	0.04
NNC	spöke	² s p øː k ə̞	ghost	привидение	prʲɪvʲɪˈdʲenʲɪjə	2	5	5	3.4201	5	5	2	1	0.07
NNC	strykjärn	² s t r yː kʝˌɛː ɳ	iron	утюг	ʊˈtʲuk	2	8	9	2.953	1	1	2	1	0.24
NNC	tass	ˈt a sː	paw	лапа	ˈłapə	1	3	4	3.1234	27	27	1	1	0.07
NNC	tegel	ˈt eː g ə̞ l	brick	кирпич	kʲɪrˈpʲiˈt͡ɕ	2	5	5	2.93	6	11	1	1	0.05
NNC	tidning	² t iː d n ɪ ŋ	newspaper	газета	gɐˈzʲetə	2	6	7	4.5669	5	5	2	1	0.05
NNC	tvål	ˈt v oː l	soap	мыло	ˈmɨłə	1	4	4	3.7527	8	10	1	1	0.05
NNC	vitlök	² v iː t l ˌ øː k	garlic	чеснок	t͡ɕɪˈsnok	2	6	6	4.2772	1	1	2	1	0.08
NNC	vykort	² v yː k ˌ ʊ ʈː	postcard	открытка	ɐtˈkrɨtkə	2	5	6	3.6678	1	1	2	1	0.08

Appendix D

An example of the picture stimuli used.

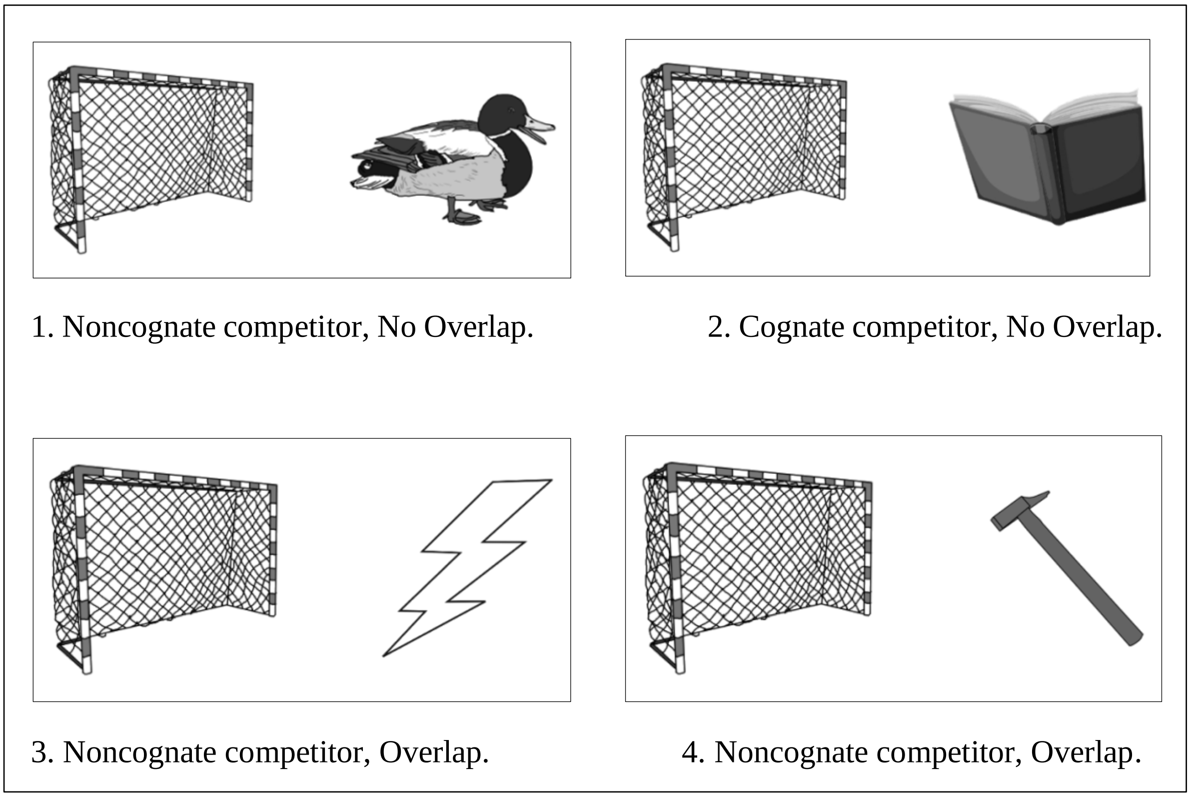

Figure D 1. An example of the visual scene for four experimental conditions for the sentence "*Han har stått i målet*" (He has stood in the goal).

The object on the left is the target noun "*mål*" (goal) and the objects on the right are competitors pronounced in Russian as follows: 1) [ˈutkə]; 2) [ˈknʲigə]; 3) [ˈmołnʲɪjə], and 4) [məłɐˈtok]. The positions of targets and competitors were counterbalanced across the experimental lists and the two blocks.

Appendix E

Table E1. Sentence stimuli: low-constraint sentences

All nouns are provided in Swedish, English and Russian. The Swedish orthographic and phonetic forms of the target nouns are provided uninflected (as they were heard in the input). The Russian translations are provided in the Cyrillic script with their IPA transcriptions.

Preamble in Swedish with English translations in parenthesis	Target noun	Non-overlapping noncognate competitor	Non-overlapping cognate competitor	Overlapping noncognate competitor	Overlapping cognate competitor
Hon har beskrivit (She has described)	**armbågen** [²arːmbˌoːgẹn] локоть [ˈłokətʲ] elbow	rök дым [dɨm] smoke	stjärna звезда [zvʲɪˈzda] star	jordnötter арахис [ɐrˈaxʲɪs] peanuts	vattenmelon арбуз [ɐrˈbus] watermelon
Hon har hittat (She has found)	**barnen** [ˈbɑː.ɳ ẹn] дети [ˈdʲetɪ] children	spegel зеркало [ˈzʲerkəłə] mirror	säck мешок [mʲɪˈʂok] sack	element батарея [bətɐˈrʲejə] radiator	torn башня [ˈbaʂnʲə] tower
Han har tecknat (He has drawn)	**benet** [ˈbeː.nẹt] нога [nɐˈga] leg	ärtor горох [gɐˈrox] peas	fisk рыба [ˈrɨbə] fish	ekorre белка [ˈbʲełkə] squirrel	underkläder белье [bʲełˈjɵ] underwear
Han har visat (He has shown)	**blomman** [²blʊmː.an] цветок [t͡svʲɪˈtok] flower	skåp шкаф [ˈʂkaf] cupboard	kanon пушка [ˈpuʂkə] canon	tefat блюдце [ˈblʲut͡sːə] saucer	pannkakor блины [blɪˈnɨ] pancakes
Hon har hittat (She has found)	**bocken** [ˈbɔkː ẹn] козел [kɐˈzɵł] goat	flygplan самолет [sɐməˈlʲɵt] airplane	nät сетка [ˈsʲetkə] net	sjukhus больница [bɐlʲˈnʲit͡sə] hospital	vinglas бокал [bəˈkal] wineglass
Han har fotograferat (He has photographed)	**bordet** [ˈbuː.ɖẹt] стол [stoł] table	klänning платье [ˈpłatʲɪjə] dress	vinge крыло [krɨˈło] wing	halsband бусы [bˈusɨ] necklace	papper бумага [bʊˈmagə] paper
Hon har visat (She has shown)	**brevet** [ˈbreː.vẹt] письмо [pʲɪsʲˈmo] letter	ost сыр [sɨr] cheese	skjorta рубашка [rʊˈbaʂkə] shirt	ögonbryn бровь [brofʲ] eyebrow	nyckelring брелок [brɪˈłok] keyring
Han har letat efter (He has looked for)	**brickan** [²brɪkː.an] поднос [pɐˈdnos] tray	fyr маяк [mɐˈjak] lighthouse	snigel улитка [ʊˈlʲitkə] snail	stock бревно [brʲɪvˈno] log	rakhyvel бритва [ˈbritvə] razor
Han har ritat (He has drawn)	**golvet** [ˈgɔlː.vẹt] пол [poł] floor	hund собака [sɐˈbakə] dog	tält палатка [pɐˈłatkə] tent	berg горы [ˈgorɨ] mountains	huvud голова [gəłɐˈva] head
Hon har frågat om (She has asked about)	**granen** [ˈgrɑː.nẹn] ёлка [ˈjɵłkə] fir-tree	borg замок [ˈzamək] castle	boll мяч [mʲæt͡ɕ] ball	kista гроб [grop] coffin	bröst грудь [grutʲ] breast
Han har sett (He has seen)	**grodan** [²gruː.dan] лягушка [lʲɪˈguʂkə] frog	tvål мыло [ˈmɨłə] soap	skepp корабль [kɐˈrablʲ] ship	svamp гриб [grʲip] mushroom	päron груша [ˈgruʂə] pear
Hon har tecknat (She has drawn)	**kalkonen** [kalˈkuː.nẹn] индейка [ɪnʲˈdʲejkə] turkey	napp соска [ˈsoskə] dummy	penna ручка [ˈrut͡ɕkə] pen	ficka карман [kɐrˈman] pocket	droppe капля [ˈkaplʲə] drop
Han har hittat (He has found)	**kavajen** [kaˈvaj.ːẹn] пиджак [pʲɪd͡ʐˈʐak] suit	fönster окно [ɐˈkno] window	ägg яйцо [jɪjˈt͡so] egg	fälla капкан [kɐpˈkan] trap	sten камень [ˈkamʲɪnʲ] stone
Hon har sett (She has seen)	**kontakten** [kɔn.ˈtakːt.ẹn] вилка [ˈviłkə] plug	räv лиса [lʲɪˈsa] fox	gräs трава [trɐˈva] grass	hjul колесо [kəlʲɪˈso] wheel	ringar кольца [ˈkolʲt͡sə] rings
Han har visat (He has shown)	**kopplet** [ˈkɔpː.lẹt] поводок [pəvɐˈdək] leash	domare судья [sʊˈdʲja] judge	bröd хлеб [xlʲep] bread	brunn колодец [kɐˈłodʲɪt͡s] well	rot корень [ˈkorʲɪnʲ] roots
Hon har beskrivit (She has described)	**krattan** [²kr atː.an] грабли [ˈgrabłɪ] rake	axel плечо [plʲɪˈt͡ɕɵ] shoulder	säl тюлень [tʲʉˈlʲenʲ] seal	färg краска [ˈkraskə] paint	mugg кружка [ˈkruʂkə] mug

Hon har ritat (She has drawn)	**krukan** [²krʉ:.kan] горшок [gɐrˈʂok] pot	orm змея [zmʲɪˈja] snake	svärd меч [mʲet͡ɕ] sword	tak крыша [ˈkrɨʂə] roof	cirkel круг [kruk] circle
Hon har tänkt på (She has thought about)	**kulorna** [²kʉ:.lʊ.ɳa] шарики [ˈʂarʲɪkɪ] marbles	spöke привидение [prʲɪvʲɪˈdʲenʲɪjə] ghost	spindel паук [pɐˈuk] spider	näve кулак [kʊˈɫak] fist	jacka куртка [ˈkurtkə] jacket
Han har tittat på (He has looked at)	**lådan** [²lo:d.an] ящик [ˈjæɕːɪk] drawer	säng кровать [krɐˈvatʲ] bed	sångare певица [pʲɪˈvʲit͡sə] singer	panna лоб [ɫop] forehead	båt лодка [ˈɫotkə] boat
Hon har ritat (She has drawn)	**lågan** [²lo:g.an] пламя [ˈpɫamʲə] flame	bil машина [mɐˈʂɨnə] car	skalle череп [ˈt͡ɕerʲɪp] skull	sked ложка [ˈɫoʂkə] spoon	häst лошадь [ˈɫoʂətʲ] horse
Han har fotograferat (He has photographed)	**lastbilen** [²las:tbˌi:l.ẹn] грузовик [grʊzɐˈvʲik] truck	vykort открытка [ɐtˈkrɨtkə] postcard	honung мед [mʲøt] honey	handflata ладонь [ɫɐˈdonʲ] palm	svala ласточка [ˈɫastət͡ɕkə] swallow
Han har tänkt på (He has thought about)	**leksakerna** [²le:k.sˌɑ:kẹ.ɳa] игрушка [ɪˈgruʂkə] toy	kvinna женщина [ˈʐɛnʲɕːɪnə] woman	väst жилет [ʐɨˈlʲet] vest	skog лес [lʲes] forest	svan лебедь [ˈlʲebʲɪtʲ] swan
Han har frågat om (He has asked about)	**målet** [ˈmo:.lẹt] ворота [vɐˈrotə] goal	and утка [ˈutkə] duck	bok книга [ˈknʲigə] book	blixt молния [ˈmoɫnʲɪjə] lightning	hammare молоток [məɫɐˈtok] hammer
Hon har fotograferat (She has photographed)	**masken** [ˈma s:kẹn] червяк [t͡ɕɪrˈvʲak] worm	knapp пуговица [ˈpugəvʲɪt͡sə] button	läpp губы [ˈgubɨ] lips	smör масло [ˈmasɫə] butter	olja масло [ˈmasɫə] oil
Han har frågat om (He has asked about)	**molnet** [ˈmo:.lẹt] облако [ˈobɫəkə] cloud	tidning газета [gɐˈzʲetə] newspaper	tunga язык [jɪˈzɨk] tongue	hjärna мозг [mosk] brain	bro мост [most] bridge
Hon har hittat (She has found)	**nallen** [²nal:.ẹn] мишка [mʲɪˈʂkə] teddy-bear	strykjärn утюг [ʊˈtʲuk] iron	kork пробка [ˈpropkə] cork	hörlurar наушники [nɐˈuʂnʲɪkʲɪ] earphones	pump насос [nɐˈsos] pump
Hon har kollat på (She has looked at)	**paraplyet** [paraplˈy:.ẹt] зонт [zont] umbrella	kyrka церковь [ˈt͡sɛrkəfʲ] church	buske куст [kust] bush	frisör парикмахер [pərʲɪkˈmaxʲɪr] hairdresser	finger палец [ˈpalʲɪt͡s] finger
Han har kollat på (He has looked at)	**pengarna** [ˈpẹŋ:.a. ŋa] деньги [ˈdʲenʲgɪ] money	jordgubbe клубника [kɫʊbˈnʲikə] strawberry	hår волосы [ˈvoɫəsɨ] hair	tupp петух [pʲɪˈtux] cock	fjäder перо [pʲɪˈro] feather
Hon har sett (She has seen)	**penseln** [²pẹn:.sẹln] кисть [kʲisʲtʲ] brush	haj акула [ɐˈkuɫə] shark	nudlar лапша [ɫɐpˈʂa] noodles	handske перчатки [pʲɪrˈt͡ɕatkɪ] gloves	sandlåda песочница [pʲɪˈsot͡ɕnɪt͡sə] sandbox
Han har beskrivit (He has described)	**piskan** [²pɪs:.kan] кнут [ˈknʊt] whip	sköldpadda черепаха [t͡ɕɪrʲɪˈpaxə] turtle	mustasch усы [ʊˈsɨ] moustache	öl пиво [ˈpʲivə] beer	såg пила [pʲɪˈɫa] saw
Hon har beskrivit (She has described)	**pojken** [²pɔj:.kẹn] мальчик [ˈmalʲt͡ɕɪk] boy	däck шины [ˈʂɨnə] tyres	skidor лыжи [ˈɫɨʐɨ] skis	hylla полка [ˈpoɫkə] shelf	läppstift помада [pəˈmadə] lipstick
Han har visat (He has shown)	**resväskan** [²re:s.vˌẹs:.kan] чемодан [t͡ɕɪmɐˈdan] suitcase	fågel птица [ˈptʲit͡sə] bird	träd дерево [ˈdʲerʲɪvə] tree	ögonfransar ресницы [rʲɪˈsnʲit͡sɨ] eyelashes	bälte ремень [rʲɪˈmʲenʲ] belt
Hon har letat efter (She has looked for)	**rocken** [ˈrɔk:.ẹn] пальто [pɐlʲˈto] coat	glass мороженое [mɐˈroʐɨnəɪ̯ə] ice-cream	hus дом [dom] house	eluttag розетка [rɐˈzʲetkə] socket	horn рог [rok] horn
Han har ritat (He has drawn)	**servitrisen** [sẹr.vɪ. ˈtri:.sẹn] официантка [ɐfʲɪt͡sɨˈantkə] waitress	tegel кирпич [kʲɪrˈpʲiˈt͡ɕ] brick	klocka часы [t͡ɕɪˈsɨ] clock	örhänge серьги [ˈsʲerʲˈgɪ] earrings	hjärta сердце [ˈsʲert͡sə] heart

Hon har tittat på (She has looked at)	**skräpet** [ˈskrɛː.pe̝t] мусор [ˈmusər] trash	plånbok кошелек [kəʂɨˈlʲøk] wallet	bi пчела [p͡tɕɪˈɫa] bee	fiol скрипка [ˈskrʲipkə] violin	bänk скамейка [skɐˈmʲeɪjkə] bench
Han har tittat på (He has looked at)	**spiken** [ˈspiː.ke̝n] гвоздь [gvosʲtʲ] nail	tass лапа [ˈɫapə] paw	pumpa тыква [ˈtɨkvə] pumpkin	rygg спина [spʲɪˈna] back	lista список [spˈɪsək] list
Hon har tittat på (She has looked at)	**stigen** [ˈstiː.ge̝n] дорожка [dɐˈroʂkə] path	kedja цепь [t͡sɛpʲ] chain	arm рука [rʊˈka] arm	mur стена [sʲtʲɪˈna] wall	glas стакан [stɐˈkan] glass
Hon har tecknat (She has drawn)	**struten** [ˈstrʉː.te̝n] рожок [rəˈʐok] cone	handduk полотенце [pəɫɐˈtʲent͡sə] towel	ballong шарик [ˈʂarʲɪk] balloon	pil стрела [strʲɪˈɫa] arrow	fot ступня [stʊˈpnʲa] foot
Hon har tecknat (She has drawn)	**svansen** [ˈsvanː.se̝n] хвост [xvost] tail	vitlök чеснок [t͡ɕɪˈsnok] garlic	måne луна [ɫʊˈna] moon	ljus свеча [svʲɪˈt͡ɕa] candle	präst священник [svʲɪˈɕːenʲːɪk] priest
Han har letat efter (He has looked for)	**tändaren** [²te̝nː.da.re̝n] зажигалка [zəʐɨˈgaɫkə] lighter	fåtölj кресло [ˈkrʲesɫə] armchair	hårborste расческа [rɐɕˈt͡ɕɵskə] hairbrush	skugga тень [tʲenʲ] shadow	vagn тележка [tʲɪˈlʲeʐkə] wagon
Hon har kollat på (She has looked at)	**tavlan** [²tɑːv.lan] картина [kɐrˈtʲinə] painting	får овца [ɐfˈt͡sa] sheep	fluga муха [ˈmuxə] fly	midja талия [ˈtalʲɪjə] waist	dansare танцор [ˈtanˈt͡sor] dancer
Han har kollat på (He has looked at)	**trumman** [²trɵmː.an] барабан [bərɐˈban] drum	igelkott ёж [ˈjoʂ] hedgehog	hov копыто [kɐˈpɨtə] hoof	käpp трость [trostʲ] cane	pipa трубка [ˈtrupkə] pipe
Hon har sett (She has seen)	**ugglan** [²ɵgː.lan] сова [sɐˈva] owl	kylskåp холодильник [xəɫɐˈdʲilʲnʲɪk] fridge	lås замок [zɐˈmok] lock	hörn угол [ˈugəɫ] corner	kol уголь [ˈugəlʲ] coal
Han har tänkt på (He has thought about)	**valpen** [ˈvalː.pe̝n] щенок [ɕːɪˈnok] puppy	gunga качели [kɐˈt͡ɕelʲɪ] swings	regn дождь [doɕːtʲ] rain	sylt варенье [vɐˈrʲenʲjə] jam	badkar ванна [ˈvanːə] bathtube
Hon har fotograferat (She has photographed)	**väskan** [²ve̝sː.kan] сумка [ˈsumkə] bag	fängelse тюрьма [tʲʉrʲˈma] prinson	hål дыра [dɨˈra] hole	gren ветка [ˈvʲetkə] branch	kamel верблюд [vʲɪrˈblʲut] camel
Hon har letat efter (She has looked for)	**växthuset** [²ve̝kːst.hˌʉː.se̝t] теплица [tʲɪˈplʲit͡sə] greenhouse	skål чашка [ˈt͡ɕaʂkə] bowl	elefant слон [sɫon] elephant	häxa ведьма [ˈvʲedʲmə] witch	rep веревка [vʲɪˈrʲɵfkə] rope
Han har frågat om (He has asked about)	**växten** [ˈve̝kː.ste̝n] растение [rɐˈsʲtʲenʲɪjə] plant	slips галстук [ˈgaɫstʊk] tie	tår слеза [slʲɪˈza] tear	skinka ветчина [vʲɪt͡ɕːɪˈna] ham	cykel велосипед [vʲɪɫəsʲɪˈpʲet] bicycle
Han har tänkt på (He has thought about)	**verktygen** [²ve̝rːk.tˌyː.ge̝n] инструменты [ɪnstrʊˈmʲentɪ] tools	mössa шапка [ˈʂapkə] hat	potatis картошка [kɐrˈtoʂkə] potato	hink ведро [vʲɪˈdro] bucket	helikopter вертолет [vʲɪrtɐˈlʲɵt] helicopter

Table E2. Sentence stimuli: high-constraint sentences

All nouns are provided in Swedish, English and Russian. The Swedish orthographic and phonetic forms of the target nouns are provided uninflected (as they were heard in the input). The Russian translations are provided in the Cyrillic script with their IPA transcriptions.

Preamble in Swedish with English translations in parenthesis	Target noun	Non-overlapping noncognate competitor	Non-overlapping cognate competitor	Overlapping noncognate competitor	Overlapping cognate competitor
Hon har opererat (She has operated)	**armbågen** [²arːmbˌoːge̩n] локоть [ˈɫokətʲ] elbow	rök дым [dɨm] smoke	stjärna звезда [zvʲɪˈzda] star	jordnötter арахис [ɐˈraxʲɪs] peanuts	vattenmelon арбуз [ɐrˈbus] watermelon
Hon har pratat med (She has talked to)	**barnen** [ˈbɑː.ɳ e̩n] дети [ˈdʲetɪ] children	spegel зеркало [ˈzʲerkəɫə] mirror	säck мешок [mʲɪˈʂok] sack	element батарея [bətɐˈrʲejə] radiator	torn башня [ˈbaʂnʲə] tower
Han har brutit (He has broken)	**benet** [ˈbeː.ne̩t] нога [nɐˈga] leg	ärtor горох [gɐˈrox] peas	fisk рыба [ˈrɨbə] fish	ekorre белка [ˈbʲeɫkə] squirrel	underkläder белье [bʲeɫˈjə] underwear
Han har vattnat (He has watered)	**blomman** [²blʊmː.an] цветок [t͡svʲɪˈtok] flower	skåp шкаф [ˈʂkaf] cupboard	kanon пушка [ˈpuʂkə] canon	tefat блюдце [ˈblʲut͡sːə] saucer	pannkakor блины [blɪˈnɨ] pancakes
Hon har matat (She has fed)	**bocken** [ˈbɔkː e̩n] козел [kɐˈzəɫ] goat	flygplan самолет [sɐməˈlʲət] airplane	nät сетка [ˈsʲetkə] net	sjukhus больница [bɐlʲˈnʲit͡sə] hospital	vinglas бокал [bəˈkal] wineglass
Han har monterat (He has assembled)	**bordet** [ˈbuː.ɖe̩t] стол [stoɫ] table	klänning платье [ˈpɫatʲjə] dress	vinge крыло [krɨˈɫo] wing	halsband бусы [bˈusɨ] necklace	papper бумага [bʊˈmagə] paper
Hon har skrivit (She has written)	**brevet** [ˈbreː.ve̩t] письмо [pʲɪsʲˈmo] letter	ost сыр [sɨr] cheese	skjorta рубашка [rʊˈbaʂkə] shirt	ögonbryn бровь [brofʲ] eyebrow	nyckelring брелок [brɪˈɫok] keyring
Han har serverat med (He has served with)	**brickan** [²brɪkː.an] поднос [pɐˈdnos] tray	fyr маяк [mɐˈjak] lighthouse	snigel улитка [ʊˈlʲitkə] snail	stock бревно [brʲɪvˈno] log	rakhyvel бритва [ˈbritvə] razor
Han har polerat (He has polished)	**golvet** [ˈgɔlː.ve̩t] пол [poɫ] floor	hund собака [sɐˈbakə] dog	tält палатка [pɐˈɫatkə] tent	berg горы [ˈgorɨ] mountains	huvud голова [gəɫɐˈva] head
Hon har planterat (She has planted)	**granen** [ˈgrɑː.ne̩n] ёлка [ˈjəɫkə] fir-tree	borg замок [ˈzamək] castle	boll мяч [mʲæt͡ɕ] ball	kista гроб [grop] coffin	bröst грудь [grutʲ] breast
Han har matet (He has fed)	**grodan** [²gruː.dan] лягушка [lʲɪˈguʂkə] frog	tvål мыло [ˈmɨɫə] soap	skepp корабль [kɐˈrablʲ] ship	svamp гриб [grʲip] mushroom	päron груша [ˈgruʂə] pear
Hon har matat (She has fed)	**kalkonen** [kalˈkuː.ne̩n] индейка [ɪnʲˈdʲejkə] turkey	napp соска [ˈsoskə] dummy	penna ручка [ˈrut͡ɕkə] pen	ficka карман [kɐrˈman] pocket	droppe капля [ˈkaplʲə] drop
Han har sytt (He has sewn)	**kavajen** [kaˈvaj.ːe̩n] пиджак [pʲɪd͡ʐˈʐak] suit	fönster окно [ɐˈkno] window	ägg яйцо [jɪjˈt͡so] egg	fälla капкан [kɐpˈkan] trap	sten камень [ˈkamʲɪnʲ] stone
Hon har kopplat i (She has set in)	**kontakten** [kɔn.ˈtakːt.e̩n] вилка [ˈviɫkə] plug	räv лиса [lʲɪˈsa] fox	gräs трава [trɐˈva] grass	hjul колесо [kəlʲɪˈso] wheel	ringar кольца [ˈkolʲt͡sə] rings
Han har satt på (He has put on)	**kopplet** [ˈkɔpː.le̩t] поводок [pəvɐˈdok] leash	domare судья [sʊˈdʲja] judge	bröd хлеб [xlʲep] bread	brunn колодец [kɐˈɫodʲɪt͡s] well	rot корень [ˈkorʲɪnʲ] roots
Hon har rensat med (She has tidied up)	**krattan** [²kr atː.an] грабли [ˈgrablɪ] rake	axel плечо [plʲɪˈt͡ɕo] shoulder	säl тюлень [tʲʉˈlʲenʲ] seal	färg краска [ˈkraskə] paint	mugg кружка [ˈkruʂkə] mug
Han har planterat i (He has planted in)	**krukan** [²krʉː.kan] горшок [gɐrˈʂok] pot	orm змея [zmʲɪˈja] snake	svärd меч [mʲet͡ɕ] sword	tak крыша [ˈkrɨʂə] roof	cirkel круг [kruk] circle

Hon har rullat (She has rolled)	**kulorna** [²kʉː.lʊ.ɳa] шарики [ˈʂarʲɪkɪ] marbles	spöke привидение [prʲɪvʲɪˈdʲenʲɪjə] ghost	spindel паук [pɐˈuk] spider	näve кулак [kʊˈɫak] fist	jacka куртка [ˈkurtkə] jacket
Han har dragit ut (He has pulled out)	**lådan** [²loːd.an] ящик [ˈjæɕːɪk] drawer	säng кровать [krɐˈvatʲ] bed	sångare певица [pʲɪˈvʲit͡sə] singer	panna лоб [ɫop] forehead	båt лодка [ˈɫotkə] boat
Hon har tänt (She has ignited)	**lågan** [²loːg.an] пламя [ˈpɫamʲə] flame	bil машина [mɐˈʂɨnə] car	skalle череп [ˈt͡ɕerʲɪp] skull	sked ложка [ˈɫoʂkə] spoon	häst лошадь [ˈɫoʂətʲ] horse
Han har kört (He has driven)	**lastbilen** [²lasːtbˌiːl.ɛ̞n] грузовик [grʊzɐˈvʲik] truck	vykort открытка [ɐtˈkrɨtkə] postcard	honung мед [mʲɵt] honey	handflata ладонь [ɫɐˈdonʲ] palm	svala ласточка [ˈɫastət͡ɕkə] swallow
Han har spritt ut (He has spread out)	**leksakerna** [²leːk.sˌɑːkɛ̞.ɳa] игрушка [ɪˈgruʂkə] toy	kvinna женщина [ˈʐɛnʲɕːɪnə] woman	väst жилет [ʐɨˈlʲet] vest	skog лес [lʲes] forest	svan лебедь [ˈlʲebʲɪtʲ] swan
Han har stått i (He has stood in)	**målet** [ˈmoː.lɛ̞t] ворота [vɐˈrotə] goal	and утка [ˈutkə] duck	bok книга [ˈknʲigə] book	blixt молния [ˈmoɫnʲɪjə] lightning	hammare молоток [məɫɐˈtok] hammer
Hon har dödat (She has killed)	**masken** [ˈma sː.kɛ̞n] червяк [t͡ɕɪrˈvʲak] worm	knapp пуговица [ˈpugəvʲɪt͡sə] button	läpp губы [ˈgubɨ] lips	smör масло [ˈmasɫə] butter	olja масло [ˈmasɫə] oil
Han har flugit i (He has flown in)	**molnet** [ˈmoː.lɛ̞t] облако [ˈobɫəkə] cloud	tidning газета [gɐˈzʲetə] newspaper	tunga язык [jɪˈzɨk] tongue	hjärna мозг [mosk] brain	bro мост [most] bridge
Hon har kramat (She has hugged)	**nallen** [²nalː.ɛ̞n] мишка [mʲɪˈʂkə] teddy-bear	strykjärn утюг [ʊˈtʲuk] iron	kork пробка [ˈpropkə] cork	hörlurar наушники [nɐˈuʂnʲɪkʲɪ] earphones	pump насос [nɐˈsos] pump
Hon har fällt upp (She has opened up)	**paraplyet** [paraˈplyː.ɛ̞t] зонт [zont] umbrella	kyrka церковь [ˈt͡sɛrkəfʲ] church	buske куст [kust] bush	frisör парикмахер [pərʲɪkˈmaxʲɪr] hairdresser	finger палец [ˈpalʲɪt͡s] finger
Han har tjänat (He has earned)	**pengarna** [ˈpɛ̞ŋː.a. ŋa] деньги [ˈdʲenʲgɪ] money	jordgubbe клубника [kɫʊbˈnʲikə] strawberry	hår волосы [ˈvoɫəsɨ] hair	tupp петух [pʲɪˈtux] cock	fjäder перо [pʲɪˈro] feather
Hon har målat med (She has painted with)	**penseln** [²pɛ̞nː.sɛ̞ln] кисть [kʲisʲtʲ] brush	haj акула [ɐˈkuɫə] shark	nudlar лапша [ɫɐpˈʂa] noodles	handske перчатки [pʲɪrˈt͡ɕatkɪ] gloves	sandlåda песочница [pʲɪˈsot͡ɕnʲɪt͡sə] sandbox
Han har slagit med (He has hit with)	**piskan** [²pɪsː.kan] кнут [ˈknʊt] whip	sköldpadda черепаха [t͡ɕɪrʲɪˈpaxə] turtle	mustasch усы [ʊˈsɨ] moustache	öl пиво [ˈpʲivə] beer	såg пила [pʲɪˈɫa] saw
Hon har träffat (She has med)	**pojken** [²pɔjː.kɛ̞n] мальчик [ˈmalʲt͡ɕɪk] boy	däck шины [ˈʂɨnə] tyres	skidor лыжи [ˈɫɨʐɨ] skis	hylla полка [ˈpoɫkə] shelf	läppstift помада [pəˈmadə] lipstick
Hon har checkat in (She has checked in)	**resväskan** [²reːs.vˌɛsː.kan] чемодан [t͡ɕɪmɐˈdan] suitcase	fågel птица [ˈptʲit͡sə] bird	träd дерево [ˈdʲerʲɪvə] tree	ögonfransar ресницы [rʲɪˈsnʲit͡sɨ] eye-lashes	bälte ремень [rʲɪˈmʲenʲ] belt
Hon har sytt (She has sewn)	**rocken** [ˈrɔkː.ɛ̞n] пальто [pɐlʲˈto] coat	glass мороженое [mɐˈroʐɨnəɪ̯ə] ice-cream	hus дом [dom] house	eluttag розетка [rɐˈzʲetkə] socket	horn рог [rok] horn
Han har pratat med (He has talked to)	**servitrisen** [sɛ̞r.vɪ. ˈtriː.sɛ̞n] официантка [ɐfʲɪt͡sɨˈantkə] waitress	tegel кирпич [kʲɪrˈpʲiˈt͡ɕ] brick	klocka часы [t͡ɕɪˈsɨ] clock	örhänge серьги [ˈsʲerʲˈgɪ] earrings	hjärta сердце [ˈsʲert͡sə] heart
Hon har samlat ihop (She has collected)	**skräpet** [ˈskrɛː.pɛ̞t] мусор [ˈmusər] trash	plånbok кошелек [kəʂɨˈlʲɵk] wallet	bi пчела [pt͡ɕɪˈɫa] bee	fiol скрипка [ˈskrʲipkə] violin	bänk скамейка [skɐˈmʲeɪjkə] bench

Han har byggt med (He has built with)	**spiken** [ˈspiː.kẹn] гвоздь [gvosʲtʲ] nail	tass лапа [ˈłapə] paw	pumpa тыква [ˈtɨkvə] pumpkin	rygg спина [spʲɪˈna] back	lista список [spˈɪsək] list
Hon har promenerat på (She has walked on)	**stigen** [ˈstiː.gẹn] дорожка [dɐˈroʂkə] path	kedja цепь [t͡sɛpʲ] chain	arm рука [rʊˈka] arm	mur стена [sʲtʲɪˈna] wall	glas стакан [stɐˈkan] glass
Hon har ätit (She has eaten)	**struten** [ˈstrʉː.tẹn] рожок [rəˈʐok] cone	handduk полотенце [pəłɐˈtʲent͡sə] towel	ballong шарик [ˈʂarʲɪk] balloon	pil стрела [strʲɪˈła] arrow	fot ступня [stʊˈpnʲa] foot
Hon har dragit i (She has pulled)	**svansen** [ˈsvanː.sẹn] хвост [xvost] tail	vitlök чеснок [t͡ɕɪˈsnok] garlic	måne луна [łʊˈna] moon	ljus свеча [svʲɪˈt͡ɕa] candle	präst священник [svʲɪˈɕːenʲːɪk] priest
Han har öppnat upp (He has opened)	**tändaren** [^{2}tẹnː.da.rẹn] зажигалка [zəʐɨˈgałkə] lighter	fåtölj кресло [ˈkrʲesłə] armchair	hårborste расческа [rɐɕˈt͡ɕɵskə] hairbrush	skugga тень [tʲenʲ] shadow	vagn тележка [tʲɪˈlʲeʐkə] wagon
Hon har hägt upp (She has hung up)	**tavlan** [^{2}tɑːv.lan] картина [kɐrˈtʲinə] painting	får овца [ɐfˈt͡sa] sheep	fluga муха [ˈmuxə] fly	midja талия [ˈtalʲɪjə] waist	dansare танцор [ˈtanˈt͡sor] dancer
Han har spelat på (He has played)	**trumman** [^{2}trɵmː.an] барабан [bərɐˈban] drum	igelkott ёж [ˈjɵʂ] hedgehog	hov копыто [kɐˈpɨtə] hoof	käpp трость [trostʲ] cane	pipa трубка [ˈtrupkə] pipe
Hon har matat (She has fed)	**ugglan** [^{2}ɵgː.lan] сова [sɐˈva] owl	kylskåp холодильник [xəłɐˈdʲilʲnʲɪk] fridge	lås замок [zɐˈmok] lock	hörn угол [ˈugəł] corner	kol уголь [ˈugəlʲ] coal
Hon har kramat (She has hugged)	**valpen** [ˈvalː.pẹn] щенок [ɕːɪˈnok] puppy	gunga качели [kɐˈt͡ɕelʲɪ] swings	regn дождь [doɕːtʲ] rain	sylt варенье [vɐˈrʲenʲjə] jam	badkar ванна [ˈvanːə] bathtube
Han har sytt (He has sewn)	**väskan** [^{2}vẹsː.kan] сумка [ˈsumkə] bag	fängelse тюрьма [tʲʉrʲˈma] prinson	hål дыра [dɨˈra] hole	gren ветка [ˈvʲetkə] branch	kamel верблюд [vʲɪrˈblʲut] camel
Hon har vattnat i (She has watered in)	**växthuset** [^{2}vẹkːst.hˌʉː.sẹt] теплица [tʲɪˈplʲit͡sə] greenhouse	skål чашка [ˈt͡ɕaʂkə] bowl	elefant слон [słon] elephant	häxa ведьма [ˈvʲedʲmə] witch	rep веревка [vʲɪˈrʲɵfkə] rope
Han har vattnat (He has watered)	**växten** [ˈvẹkː.stẹn] растение [rɐˈsʲtʲenʲɪjə] plant	slips галстук [ˈgałstʊk] tie	tår слеза [slʲɪˈza] tear	skinka ветчина [vʲɪt͡ɕːɪˈna] ham	cykel велосипед [vʲɪłəsʲɪˈpʲet] bicycle
Han har byggt med (He has built with)	**verktygen** [^{2}vẹrːk.tˌyː.gẹn] инструменты [ɪnstrʊˈmʲentɪ] tools	mössa шапка [ˈʂapkə] hat	potatis картошка [kɐrˈtoʂkə] potato	hink ведро [vʲɪˈdro] bucket	helikopter вертолет [vʲɪrtɐˈlʲɵt] helicopter

Appendix F

List of the glosses used in this paper (The Leipzig Glossing Rules (2008) were used):

ART. – Article

C. – Common gender

DEF. – Definite

F. – Feminine gender

N. – Neuter gender

INF. – Infinitive

PL. – Plural

PRS. – Present

PTCP – Participle

SG. – Singular

Stockholms universitet
106 91 Stockholm
Telefon: 08–16 20 00
www.su.se

Stockholms universitet