



DEVELOPMENT OF ‘SPEECH UNDERSTANDING IN NOISE TEST’ FOR THE SLOVAK LANGUAGE

Dominika Húdoková^{1,2*} Vojtech Chmelík² Monika Rychtáriková^{1,2} Astrid Van Wieringen³

¹ KU Leuven, Department of Architecture, Campus Brussels and Ghent, Belgium

² STU Bratislava, Department of Materials Engineering and Physics, Slovakia

³ KU Leuven, Department of Neurosciences, Research Group ExpORL, Belgium

ABSTRACT

The growing awareness of the importance of speech intelligibility in Slovakia uncovered the need for the development of a ‘Speech understanding in noise test’ for the Slovak language. This article reports on the preparation of the speech material for the ‘Speech understanding in noise tests’ and highlights challenges in understanding Slovak in noisy conditions and identifies common mistakes: (1) confused words, (2) word spelling errors, (3) incorrect verb conjugation, and (4) pronoun mistakes. The importance of exploring speech intelligibility in a diverse range of languages, including those with less commonly studied languages and smaller populations, is emphasized by this study.

Keywords: *speech intelligibility, speech understanding in noise test, Slovak language*

1. INTRODUCTION

This paper aims to describe the challenges of the Slovak language in the context of Speech Understanding in Noise Test. Specifically, it focuses on the development of Sentence Test Material for testing speech perception in noisy Environments. In speech intelligibility research, the use of sentence material in ‘Speech understanding in noise tests’ mimics real-world listening situations. The use of sentence material also enables researchers to examine various linguistic features that are essential for successful communication, including grammar, vocabulary, and syntax. Many authors have explored the impact of speech understanding in noise in listening tests that involve

sentence materials in various languages, including American English [1], British English [2], Finnish [2], Norwegian [3], Swedish [4], Spanish [5], German [6], Dutch [7], Danish [8], Polish [9], Japanese [10], Farsi [11], Mandarin [12], Telugu [13], Flemish [14], and French [15]. Choosing appropriate test materials is essential for accurately assessing speech intelligibility and guiding proper interventions for individuals with speech difficulties. The development of a well-balanced Sentence Test Material for Speech Understanding in Noise Tests is important. However, there is a notable deficiency in audiological and acoustical research regarding the Slovak language, specifically the lack of proper materials for evaluating speech intelligibility. Consequently, our current research efforts are focused on addressing this gap through the development of appropriate speech material. Well-balanced Sentence Test Material refers to a set of sentences that are carefully selected and designed to ensure that they are representative of the language being tested, as well as being similar in complexity and difficulty when presented in noise. Furthermore, a “well- balanced” set of sentences is carefully designed to avoid any biases or confounding factors that may influence the outcomes of the listening test and validated in noise. Ultimately, the goal is to create a set of sentences that accurately reflects the language being tested and provides a reliable and valid measure of speech perception in challenging listening environments.

2. METHODS

The creation of a Sentence Test Material for Speech Understanding in Noise for the Slovak language follows several steps [14]. This paper will detail the initial steps involved in developing a sentence database for the Slovak language, as well as the challenges encountered during this process. In the initial phase of the listening test, a fixed

*Corresponding author: dominika.hudokova@kuleuven.be

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method was used, entailing the evaluation of sentence material at specific signal-to-noise ratios. Subsequently, following a statistical analysis and the removal of unsuitable sentences, a second round of the listening test was conducted using an adaptive method. After further statistical analysis, we created well-balanced sentence sets. More information regarding the method and outcomes about the creation of the Slovak sentence test material can be readily accessed through reference [16], presently to be submitted to the International Journal of Audiology.

2.1 Development of Sentence Test Material

The present study reports the development of the Slovak Sentence Test Material, which consists of 500 simple and neutral sentences at the beginning of the experiment. The development was based on the expertise of van Wieringen and Wouters [14]. The sentences included in the Slovak Sentence Test Material were designed to be easily repeated by test participants. They are short and devoid of proper names, proverbs, difficult words, exclamations, or questions. The authors drew inspiration from texts in newspapers, novels, and online lifestyle blogs to construct natural-sounding sentences in the initial written form. The sentences comprise a minimum of two and a maximum of eight words, each containing at least one verb and noun. To simulate everyday-life communications, the sentences feature ordinary, everyday-life vocabulary. Importantly, each sentence is grammatically and semantically correct, and predictable. Each sentence is assigned a unique code number, which is used in the programming process of the test application to facilitate the identification and retrieval of individual sentences for use in the testing protocol. The Slovak Sentence Test Material was recorded by a female speaker who kept a consistent speech pace and articulation throughout the entire recording session. The fundamental frequency of her voice was 275 Hz, and the average speaking rate was 5 syllables per second. The recordings were performed under controlled acoustic conditions to ensure that the speech samples were of high quality without the influence of the room acoustic conditions and free from external noise sources.

3. CHALLENGES IN ‘SPEECH UNDERSTANDING IN NOISE TEST’ FOR THE SLOVAK LANGUAGE

In contemporary times, listening tests continue to be conducted for the development of well-balanced sentence test material. The primary focus of this paper is to illustrate the challenges encountered when evaluating the Slovak

language in the context of Speech Understanding in Noise Tests.

3.1 Slovak language

The Slovak language belongs to the West Slavic branch of the Slavic language family, which includes other languages such as Czech, Polish, and Sorbian. The Slovak language has a complex grammar system with seven cases, three genders, and two numbers. It also has a rich vocabulary and a unique phonetic system with a variety of consonants and vowels, including some sounds that are not found in other Slavic languages. The Slovak consonants can be divided into several categories based on their phonetic properties: (a) voiceless and voiced, (b) plosive and affricate, (c) fricative, (d) nasal, (e) approximant, (f) lateral, (g) palatal, (h) velar, (i) bilabial, and (j) dental/alveolar. The Slovak vowels can be divided into two categories based on their phonetic properties: (1) front vowels, and (2) back vowels, which can be either short or long. There are also several diphthongs, which are combinations of two vowel sounds pronounced together. Slovak also has a system of palatalization, which involves the modification of certain consonant sounds when they occur before front vowels. This results in the creation of additional palatal consonants, which are pronounced with the tongue in a raised position near the hard palate. Compared to e.g., Anglo-Germanic languages, Slovak grammar is more inflected, meaning that the endings of words change to reflect their grammatical function. Slovak nouns, adjectives, and verbs have multiple forms depending on their gender, number, and case. Henceforth, enunciating each phoneme in the utterance becomes paramount as speech understanding is highly susceptible to misinterpretation. Throughout history, Slovak has been influenced by other languages, including Latin, German, and Hungarian. Slovak is primarily spoken in Slovakia, where it is the official language. However, there are also significant Slovak-speaking communities in neighboring countries such as Hungary, Poland, and Ukraine. Additionally, there are smaller Slovak-speaking communities in other parts of the world, including the United States, Canada, and Australia.

3.2 The most common mistakes in ‘Speech Understanding in Noise Test’ for the Slovak language

The current study aimed to investigate the intelligibility of Slovak speech in noisy listening conditions by conducting the ‘Speech Understanding in Noise Test’ with normal-hearing participants. Analysis of the pre-test results showed that several challenges to intelligible Slovak speech were found. Specifically, mistakes in pronunciation, grammar,

and vocabulary were found to be the most common challenges encountered by participants during the test sessions. These findings provide valuable insights into the factor that affect the intelligibility of Slovak speech in noisy environments and have implications for speech perception research and clinical practice. The most common mistakes in the ‘Speech Understanding in Noise Test’ for the Slovak language: (A) Confused word: The mistake of “confused words” is a common challenge met in listening tests for speech intelligibility because it involves a breakdown in the perception and processing of phonetic information. When presented with the speech in noisy listening conditions, listeners must rely on acoustic cues to perceive and understand spoken words. However, speech sounds that are similar in their acoustic properties, such as those that differ only in voicing or place of articulation, can be easily confused. In addition to acoustic confusability, lexical factors can also contribute to the mistake of confused words. Some of the most commonly confused words within the ‘Speech Understanding in Noise Test’ for the Slovak language can be found in Table 1.

Table 1. Common mistakes in the confusion of the words in the listening tests for Slovak language.

| Correct answer | Wrong answer |
|----------------|--------------|
| farby | karty |
| poplietol | doniesol |
| vytlačili | utlačili |
| beh | vek |
| mačka | hračka |
| kúpil | vstúpil |
| hrubý | druhý |
| skorím | skvelím |
| traja | dvaja |
| mladá | malá |

(B) Word spelling: This type of mistake can occur for a variety of reasons. One reason is related to the phonological encoding process, which involves mapping sounds to their corresponding phonemes and then graphemes. When listeners are presented with spoken words in noisy conditions, they may misperceive or misinterpret the phonemes, leading to errors in spelling the words. For instance, similar-sounding phonemes, such as [p] and [b], or [s] and [z], may be difficult to distinguish in noisy environments, leading to confusion and spelling errors. Another reason for the mistake in word spelling may be related to the memory and attention demands of the task.

Listening in noisy conditions can require significant cognitive effort, which may interfere with the listener’s ability to keep and recall the correct spelling of the words. Moreover, the presence of the noise may lead to attentional lapses or distraction, further impairing the listener’s ability to spell the words correctly. Some of the most common mistakes in word spelling within the ‘Speech Understanding in Noise Test’ for the Slovak language can be found in Table 2.

Table 2. Common mistakes of word spelling in the listening tests for Slovak language.

| Correct answer | Wrong answer |
|----------------|--------------|
| letisko | ihrisko |
| rozhádzané | pohádzané |
| skúškami | bruškami |
| vodiča | lupiča |
| možnosť | voľnosť |
| odviezla | odniesla |
| íst | príst |
| väčšina | dievčina |
| ponáhľat | pohádat |
| cesta | sestra |

(C) Verb conjugation: One reason for this type of error may be related to the phonological processing of verb. In some languages, including Slovak, verbs are conjugated by adding suffixes to the root form of the verb. However, different suffixes may have similar or overlapping phonetic features, leading to errors in identifying the correct suffix. For example, in Slovak, the past tense suffixes “-l” and “-ol” have similar phonetic properties, making it difficult to distinguish between them in noisy listening conditions. Another reason for the mistake of verb conjugation may be related to the syntactic and semantic processing of the sentence. In some cases, the context of the sentence may provide clues to the correct verb form, such as the tense, number, or subject. However, in noisy listening conditions, listeners may have difficulty processing the full sentence and may rely more heavily on isolated words or phonetic clues, leading to errors in verb conjugation. Some of the most common errors in verb conjugation within the ‘Speech Understanding in Noise Test’ for the Slovak language can be found in Table 3.

Table 3. Common mistakes in wrong verb conjugation in the listening tests for Slovak language.

| Correct answer | Wrong answer |
|----------------|--------------|
| hovorím | hovoril |
| bola | bol |
| pomohol | pomohla |
| premysli | premyslím |
| nevrátim | nevrátil |
| nezmestí | nezmestil |
| býval | bývam |
| našla | našie |
| pozrela | pozerám |
| vystrašil | vystraší |

(D) Word number category: This mistake refers to identifying the suffix used to write down the number category of a word (e.g., singular or plural) in a listening test for speech intelligibility. This type of mistake can occur due to several factors related to the processing of spoken language, including Slovak, the suffixes used to show the number category of a word may have similar phonetic features. The context of the sentence may provide important cues to the number category of the words used, such as subject-verb agreement or the presence of quantifiers or determiners. Some of the most common mistakes in the word number category within the ‘Speech Understanding in Noise Test’ for the Slovak language can be found in Table 4.

Table 4. Common mistakes in the word number category in the listening tests for Slovak language.

| Correct answer | Wrong answer |
|----------------|--------------|
| rastliny | rastlinu |
| zámka | zámky |
| dieťa | deti |
| riešení | riešenie |
| skúškam | skúške |
| víkendy | víkend |
| očakávanie | očakávania |

(E) Pronoun: The mistake of pronoun underscores the importance of considering multiple linguistic and cognitive factors that can affect speech perception and understanding. For example, in Slovak, the third person singular pronouns “on” (he) and “ona” (she) have similar phonetic properties, which can lead to confusion and errors in identifying the correct pronoun. Some of the most common mistakes in pronouns within the ‘Speech Understanding in Noise Test’ for Slovak language can be found in Table 5.

Table 5. Common mistakes of pronouns in the listening tests for Slovak language.

| Correct answer | Wrong answer |
|----------------|--------------|
| ma | mi |
| môj | tvoj |
| mal | má |
| mal | mám |
| ho | ma |
| mi | mu |
| jeho | jemu |
| ju | ma |
| sú | som |
| vám | nás |

4. CONCLUSION

In conclusion, this study provides valuable insights into the challenges that listeners face when trying to understand Slovak in noisy listening conditions. The results of the ‘Speech understanding in noise test’ highlight the most common mistakes that affect speech intelligibility in Slovak, including confused words, word spelling errors, incorrect verb conjugation, and pronoun mistakes. These findings have practical implications for language instruction, communication technologies, and social inclusion for Slovak-speaking individuals. Furthermore, the study underscores the importance of investigating speech intelligibility in a range of languages, including those with smaller populations and less commonly studied languages. The next stages of our ongoing research endeavour will encompass the completion of the listening test and select sentences of equal difficulty.

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