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PERSISTING GRAMMATICAL ERRORS OF MACHINE TRANSLATION[1]

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Abstract: The paper investigates the quality of machine translation (MT) and traces its development through two main approaches – Statistical Machine Translation (SMT) and Neural Machine Translation (NMT) – by comparing English-to-Slovak outputs produced by Google Translate. The aim of the paper is to evaluate the quality of MT outputs from the point of view of two typologically different languages – English, a predominantly analytic language, and Slovak, a primarily synthetic language – using a sample of newspaper texts, which are often translated by machine due to their wide vocabulary and varied subject matter. The research results indicate that NMT (obtained in 2023), compared to its predecessor SMT (obtained in 2017), has significantly improved in almost all framework categories. The NMT output is much more fluent, sounding more natural and comprehensible. In contrast, shortcomings can be found in the category of syntactic-semantic correlativeness and lexical semantics. In such cases, neural MT may struggle to select the appropriate fit-in-context meaning; moreover, these lexemes can further shift the meaning of the entire sentence, clause, or even utterance.

Keywords: machine translation quality assessment, Slovak, English, statistical MT, neural MT.

1. INTRODUCTION

As part of technological advancements, significant progress is being observed in the translation industry as well. This includes, among other developments, significant improvements to one of the most widely used and well-known machine translation systems – Google Translate (GT). Its quality, efficiency, and popularity are continually improving, and it is becoming popular among millions of users worldwide due to its free access and availability (Wang et al. 2022, p. 143; Melby 2020, p. 422). Koponen (2016, p. 131) claims that developments have shifted GT from a peripheral position to a more central role in the translation industry. Machine translation (MT) is designed for both common language users who do not have a high proficiency in the target language and professional human translators using

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MT in their computer-assisted (CAT) tools (e.g., TRADOS) to foster translation. In terms of the translation process, MT demonstrates a considerably greater improvement in productivity compared to human translation (HT). This has been empirically demonstrated in many cases over the last decade, relying on phrase--based and rule-based paradigms of MT across various text types, including technical documents (Plitt – Masselot 2010) and news (Martín – Serra 2014).

The translation industry is still evolving, and as advancements continue, different translators' competencies are required. In these terms, Bednárová-Gibová et al. (2024, p. 104) point at the fact that technological competence, subsuming the knowledge of IT applications, CAT tools, essentials of MT translation, data literacy and workflow management tools, sits at the heart of the revised 2022 EMT framework. They describe a translator as an augmented translator whose work is significantly aided and enhanced by technology.

1.1 Research objective

The primary goal of this research is to assess the MT quality and evaluate its advancements. The most frequent and significant errors in statistical machine translation (SMT) and neural machine translation (NMT) outputs will be identified, classified, and analysed. Moreover, the improvements and shortcomings of NMT compared to SMT will be highlighted. It will be compared whether a statistically significant difference exists between the two approaches used in automated translation.

Various grammar categories, focusing on predicativeness, syntactic-semantic correlativeness, and lexical semantics, which have a crucial impact on the comprehension of MT output, will also be discussed. This study builds upon research initiated by Welnitzová and Munková (2021, p. 90), which found that the most frequent errors leading to misunderstandings are related to predicativeness, nominal and verbal morpho-syntax, word order, and lexical adequacy.

1.2 Machine translation and its background

MT is defined as a fully automated process that transforms a text from one language into another without human intervention (Quah 2006, p. 2). Since this process is fully automated, the output often requires correction or revision (post-editing) by a human. The goal of post-editing is to ensure both the accuracy of the MT output (so that the target text remains faithful to the source text) and the fluency of the text.

Melby (2020, p. 419) defines the most common MT paradigms – SMT and NMT – as follows: SMT works with extensive bilingual corpora. It is based on the acquisition of a translation model and the decoding of sentences from the source text to find an adequate translation in the target text. Its aim is to create a system that would match sentences from the source text with the sentences from the target text. It creates target text using language and translation models and statistical probability.

However, the disadvantage of SMT is its limited training (translation is "trained" on one type of corpus) and equivalence (since alignment of words can be unreliable) (Munková 2017, p. 21).

NMT has appeared as a new paradigm in MT, and has been shown to improve the translation quality, regardless of the language pair (Toral – Sánchez-Cartagena 2017). It seems that translations produced by NMT are much more fluent (Bentivogli et al. 2016) compared to those derived by phase-based SMT, and that NMT does not lead to literal translations, as it was in the case of phase-based SMT. Melby also states that nowadays sufficient training data for a viable NMT system are available only for about twenty out of more than 4,000 languages in the world (2020, p. 420). The move to NMT is the most significant change in the MT approach. NMT, in principle, processes large amounts of data, translates a sentence as a whole, and therefore, in most cases, NMT output is much clearer than phrase-based SMT output. Although NMT provides a reader with seemingly more comprehensible and flawless outputs, the quality and comprehensibility of NMT output are questionable.

NMT has been brought to the fore as it has shown significant results in translations from English into French (Luong et al. 2015) and from English into German (Jean et al. 2015). It is based on neural networks, trained end-to-end, with a small memory track and its ability to generalise long sequences of words. It uses deep machine learning represented by neural networks (Bessenyei 2017), using algorithms which enable it to learn and consequently decide about translation solutions. It can process source segments (one segment usually corresponding to one sentence) and transform them into target segments, considering whole sentences, not just phrases.

Moorkens and Lewis (2020, p. 474) state that NMT is regarded as a form of weak artificial intelligence, as it determines the next transformation to perform autonomously rather than executing explicit instructions from the user. NMT requires vast quantities of human-created data for training. An example can be found at language data brokers who sell language data for MT learning system training and media stories of a boom in language data (Diño 2018).

Caffrey and Valentini (2020, pp. 142–143) claim that NMT is based on neural network models which learn from previously translated texts. NMT output produces a more natural word order than SMT. When comparing the systems, NMT frequently outperform SMT in automatic evaluations, but human evaluations are less definite (Castilho et al. 2017). In the comparison of output translated from English to Japanese using SMT and NMT, a human evaluator preferred the NMT output to the SMT output. The difference was not significant (4%), and in the overall evaluation, it can be stated that both systems (NMT and SMT) were comparable for the majority of sentences.

NMT fluency has greatly improved, albeit sometimes at the expense of adequacy. In such cases, NMT offers surprising translation solutions – it often creates sentences which seem to be fluent, but are, on the contrary, not adequate in meaning (cf. Munková 2017, p. 23).

1.3 Typological characteristics of Slovak and English in newspaper style

When analysing errors in MT outputs, it is essential to evaluate them in the context of the specific style and type of text, as well as in relation to the source and target languages. Our research examines MT outputs of newspaper texts translated from English into Slovak using two MT approaches – SMT and NMT. To fully understand the errors that occur in MT outputs, it is crucial to consider the linguistic principles of both languages within the given stylistic contexts.

Slovak is primarily classified as a synthetic language, whereas English is considered an analytic language (Dolník 2013, p. 87). According to Vaňko and Auxová (2015, p. 24), in the analytic type, grammatical meaning is expressed analytically – that is, through separate words, one of which carries lexical meaning and the other (auxiliary) conveys grammatical meaning. Analytic languages do not formally distinguish between nominative and accusative cases, and their word order is typically rigid.

In contrast, Slovak features synthetic morphology (Ondruš – Sabol 1984, p. 186). This type is manifested by the richness of forms of open class words, a marked gender differentiation of forms, the expression of a complex of grammatical meanings (e.g., gender, number, and case) by a single formal element within a word (e.g., the morpheme *-u* in the form *žen-u* (the form *woman* in the accusative case) reflects feminine gender, singular number, and the accusative case), the occurrence of synonymy and homonymy of case suffixes, and the differentiation of forms by changes at the end of the morphological base.

Based on the theoretical background and previously mentioned studies, we can state that the main differences between English and Slovak (and thus the challenges in both human and machine translation) lie in almost all examined grammatical categories. In the category of '*predicativeness*', it is agreement between the subject and verb in person, number, and gender. In the category of '*syntactic-semantic correlation*', the key aspects are '*nominal morpho-syntax*' and '*verbal morpho-syntax*' (mainly in noun phrases and verb phrases, which follow similar rules as subject-verb agreement in '*predicativeness*'), as well as word order, which is fixed in English but loose in Slovak. Word order in Slovak mostly applies the sentence pattern S – V – O. On the other hand, it is not grammatically relevant, and it does not determine the grammatical (syntactic) function of a word in a sentence. For example, the word order in the sentence *Evu ľúbi Peter*. (*Peter loves Eve*.) can be changed into *Peter ľúbi Evu*. (*Peter loves Eve*.) without any changes in the syntactic functions of nouns *Peter* and *Eva*. Fixed word order in Slovak is required within noun phrases (particularly in pre-modifiers and post-modifiers) and complements (Vaňko 2015, pp. 80–81). Moreover, serious issues in machine translation can arise because, unlike in English, the subject in Slovak can be expressed both explicitly and implicitly (e.g., ENG: *She said*. SVK: *Ona povedal-a./Povedal-a.*). The pronoun *ona* (*she*) can be omitted, and cohesion in the text is conveyed through the suffix *-a* in the verb

povedal-a (*said*, referring to the feminine gender). Noun phrases functioning as subjects and objects (mainly expressed by noun-adjective or noun-noun combinations) are structurally determined by the gender of the head noun. Inflectional endings reflect the grammatical case of an adjective or noun, thereby determine the role of the word or phrase (the subject is in the nominative case, while the object is primarily in the accusative case). Further discrepancies between English and Slovak can be found in the category of '*lexical semantics*', as English has significantly more polysemantic and homonymous words than Slovak (see Ondruš – Sabol 1984, pp. 228–229). To ensure translation adequacy in such cases is challenging, even for a human translator.

Table 1: Examples illustrating structural divergence in Slovak and English (Welnitzová 2024, p. 27).

Slovak (SVK)	**English (ENG)**
chodím (*chod-ím*)	*I go*
študenta (*študent-a*)	*of the student*
nepôjdu (*ne-pôjd-u*)	*they will not go*

The analytic form *I go* (2 words in English) is expressed by the form *chodím* (1 word in Slovak), just as the structure *of the student* (3 words in English) has the equivalent *študenta* (1 word in Slovak) (Dolník 2013, p. 88). The structure *they will not go* (4 words in English) is translated as *nepôjdu* (1 word in Slovak). It is evident that grammatical categories are expressed in different morphemes, structures, and the number of words.

Regarding the English–Slovak language pair, it is necessary to add that the number of verb tenses in the given grammar systems is different: Slovak has three grammaticalised verb tenses, while English has six simple temporal verb forms, which can also be combined with progressive forms (e.g., *I work*, *I am working*; see Dušková 2012). The ante-preterit is also recognised within the Slovak tense system (Oravec et al. 1984, p. 148); however, it is regarded as a marginal stylistic phenomenon, primarily used as a stylistic device (Vajičková 2023, p. 7) and not typically employed in newspaper style (Welnitzová et al. 2020, p. 166).

Table 2: Examples illustrating tense systems of Slovak and English.

Slovak (SVK)		**English (ENG)**	
Present	*hliadk-u-jú*	present simple	*they patrol*
Past	*hliadk-ova-l-i*	past simple	*they patroll-ed*
Future	*budú hliadk-ova-ť*	simple future	*they will patrol*
		present perfect	*they have patroll-ed*
		past perfect	*they had patroll-ed*
		future perfect	*they will have patroll-ed*

In synthetic languages, common phenomena such as synonymy and homonymy of case endings are typical. In English, the grammatical categories of gender, number, and case are morphologically marked, though not by means of declension as in the Slovak language.

In addition to the aforementioned issues, which reflect differences between English and Slovak related to grammatical and lexical equivalence, there are also challenges concerning pragmatic and textual equivalence. These include the translation of names, idioms, or geographically marked expressions (see Kvetko 2021, p. 27).

Unlike the grammar of English and Slovak, the register of the newspaper style is similar in both contexts. According to Mistrík (1989, p. 460), the newspaper style is characterised by a high frequency of nouns, numbers, abbreviations, names, and symbols, while verbs occur less frequently. He notes that within verb categories, aspect (with a perfective-to-progressive ratio of 1:2), person (with the third-person singular being the most commonly used), and tense (predominantly past tense) are particularly significant. Additionally, syntactic and grammatical constructions in this style are relatively flexible. According to Findra (2013, pp. 262–270), the primary objective of newspaper texts is to convey information to the reader; consequently, clarity and comprehensibility are essential. The newspaper style frequently employs both simple and complex sentence structures. Its lexis is relatively diverse, depending on the genre and domain. From the morphological point of view, it is characterised by predominantly nominal structures, often using personal names, surnames, geographic names, and culturally specific references (realia). Biber and Conrad (2009, p. 109) define *newspaper style* (also referred to as *newspaper writing*) in English as a style characterised by a written register, emphasising its informative function. The primary goal of this style is to report and describe events rather than interpret them. In terms of nominal features, various noun forms – including nouns, nouns used as pre-modifiers or post-modifiers, and noun phrases – are common. Regarding verbs, newspaper style primarily uses the present simple and past tense to narrate sequences of events.

The newspaper style has been labelled in various ways, such as *publicistic style*, with more recent designations including *media communication sphere* (Slančová et al. 2022, p. 300) or *the sphere of media communication* (Hlavatá et al. 2019, p. 44). However, as the term *newspaper style* is present in both Slovak and English linguistic contexts, it will be consistently applied in this study.

2. MATERIAL AND METHODS

At the beginning of research (in 2017), we created a corpus consisting of 59 newspaper articles (3,376 segments / 54,442 words) from the British online newspaper *The Guardian*. The data were pre-processed through tokenisation and

segmentation before being translated by statistical GT (in 2017) and later by neural GT (in 2023). The MT outputs, along with their original texts, were then imported into the virtual environment OSTEPERE – a system for translation, post-editing, and MT evaluation (Munková – Munk 2016; Benko – Munková 2016) – in which the texts were post-edited by professional translators.

The identification and classification of errors in the SMT and NMT outputs were performed by two Slovak language experts, who categorised and evaluated the MT errors. The MT output analysis was aligned with general error typology frameworks (e.g., Font Llitjos et al. 2005, Vilar et al. 2006, and Lommel 2018). Due to discrepancies between English and Slovak, as well as the character of texts examined, we focused on a more detailed assessment of morpho-syntactic, syntactic-semantic relations and lexical semantics – language categories with a significant number of errors in Slovak, as designed by Vaňko (2017, pp. 83–100). In this context, four key grammatical realms were examined: **1.** ***Predicativeness and Modal and communication sentence framework*** (whether the main sentence elements – the subject and predicate – are correctly identified in the source segment and accurately transferred into the target segment by MT and whether the modal framework in the source segment is identified and accurately transferred into the modal framework of the target segment by MT), **2.** ***Syntactic-semantic correlativeness*** (the correctness of expressing semantic-syntactic relationships between content words within phrases and sentences, as well as the grammatical means of their realisation [e.g., agreement, pre-modification, post-modification] is examined), **3.** ***Compound/complex sentences*** (whether the semantic relationships between sentences in the source segment are correctly transposed into the target segment – for example, the correct use of conjunctions, time shifts, and the transformation of compound/complex sentences from the source segment into compound/complex sentences in the target segment), and **4.** ***Lexical semantics*** (is closely linked to the categories of syntactic-semantic correlativeness and compound/complex sentences; an arrangement of words into grammatically correct phrases and sentences is essential; otherwise, the segment may become difficult or even impossible to understand). After identifying and classifying the MT errors according to this framework, we calculated their frequencies in the analysed newspaper texts. This analysis led to the formulation of the following research hypothesis:

H0: *There is no statistically significant difference between statistical and neural MT.*

3. RESULTS

The following section presents the research results, highlighting the occurrence of errors in specific language categories within both SMT and NMT outputs. Categories without errors are not included in the results.

Based on the results of Levene's Test for Homogeneity of Variances (Table 3), the error frequencies in SMT and NMT exhibit approximately equal variability. Therefore, Univariate tests for repeated measures can be used for the statistical verification of our hypothesis.

Table 3. Levene's Test for Homogeneity of Variances.

	MS Effect	MS Error	F	p
SMT	285.798	201.310	1.420	0.2540
NMT	27.757	20.321	1.366	0.2697

Based on the results of the test, we reject the null hypothesis, suggesting a statistically significant difference between SMT and NMT ($p = 0.002118$).

Specifically, the analysis reveals a statistically significant difference in error frequency between SMT and NMT, in favour of NMT (Table 4). On average, fewer errors were identified in NMT (5.526) compared to SMT (18.533).

Table 4. Multiple comparisons: MT.

MT	Mean	1	2
NMT	5.526	****	
SMT	18.553		****

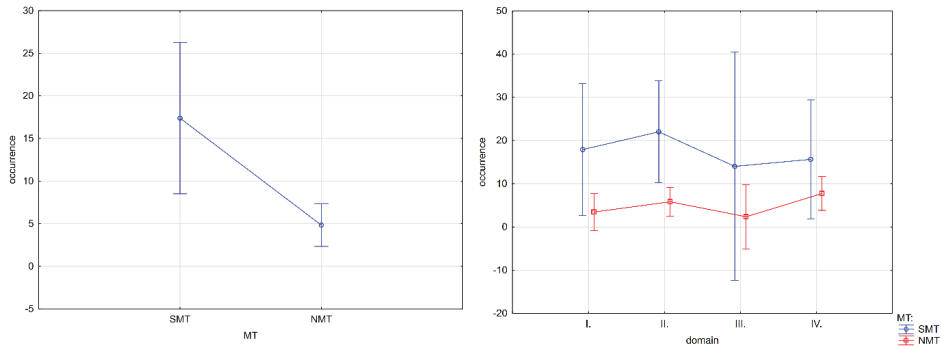

Figure 1: Error frequency for SMT and NMT a) overall b) by categories (domain).

Subsequently, we aimed to examine which specific error categories showed significant differences between SMT and NMT.

3.1 Predicativeness and Modal and communication sentence framework

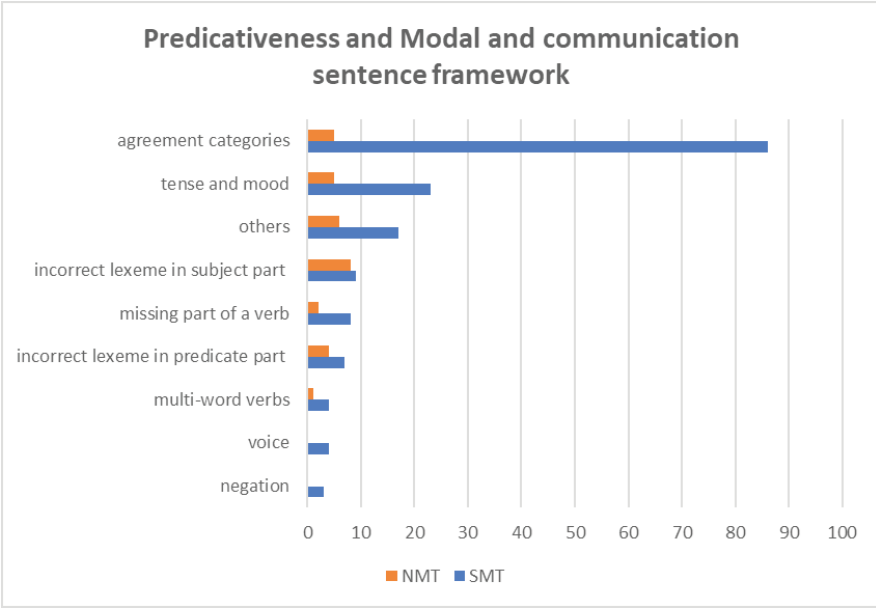

Figure 2: The results in Predicativeness and Modal and communication sentence framework for SMT and NMT.

Figure 2 shows the results in the category of *Predicativeness*, covering '*predicative categories*' ('*infinitive form of a verb*', '*missing part of a verb*', '*voice*', '*multi-word verbs*', '*incorrect lexeme in predicate part*'), '*agreement categories*' ('*agreement in person, number, gender*', '*subject and its issues*', '*incorrect lexeme in subject part*'), '*others*' (the errors which were not classified due to lacking subcategories); and in the item of *Modal and communication sentence framework*, for both SMT and NMT outputs. The most frequent errors were identified in the category of '*agreement in person*', '*number*', and '*gender*' (SMT 86, NMT 5), '*tense*' and '*mood*' (SMT 23, NMT 5), and '*other issues*' (SMT 17, NMT 6). The latter category primarily involves the English form *'s,* which can indicate either verb contraction or possessive case. These errors were, in fact, quite frequent. Errors in other categories included the following: '*incorrect lexeme in subject part*' (SMT 9, NMT 8), '*missing part of a verb*' (SMT 8, NMT 2), '*incorrect lexeme in predicate part*' (SMT 7, NMT 4), '*multi-word verbs*' (SMT 4, NMT 1), '*voice* (*active*/*passive*)' (SMT 4, NMT 0).

The highest number of errors in SMT was observed in the categories of '*agreement in person*', '*number*', and '*gender*' (Figure 2). This aligns with the typological differences between English and Slovak, as well as the nature of newspaper

texts. In such texts, nominal features – nouns in various forms (e.g., nouns, nouns used as pre-modifiers or post-modifiers, nouns within noun phrases, and noun phrases embedded in prepositional phrases) – are more prevalent. Consequently, the frequent occurrence of these structures and the related challenges (e.g., noun inflection, noun-adjective agreement, and noun-verb agreement) were anticipated.

Example (1) illustrates the improvement of machine translation in the '*category of agreement in gender*'. In SMT, for example, the structure *seasonal, casual nature of the work was often problematic* was translated as *sezónne, príležitostná povaha práce bolo často problematické*. Observing the affixes in the word, it can be concluded that the word *sezónn-e* refers to the neuter gender, the noun phrase *príležitostn-á povaha* refers to the feminine gender, the verb structure *bolo problematické* to the neuter gender (the correct structure is *sezónny, neplánovaný charakter práce bol často problematický*, with all these words referring to the same gender, as shown below, which displays the human translation (HT). We can say that the level of agreement in the given SMT subject-verb structure is relatively low. On the contrary, NMT suggests the translation *sezónny, príležitostný charakter práce bol často problematický* which is correct. All adjectives (*sezónny*, *príležitostný*, *problematický*) correspond with the noun (*charakter*) and the auxiliary verb (*bol*) in the '*category of gender*' (as well as in '*number*' and '*case*'). We can conclude that the improvement in the categories of '*agreement in person*', '*number*', and '*gender*' is significant, and that the NMT output is much more comprehensible than the SMT output:

(1)

ST: *They acknowledged that the **seasonal, casual nature** of the work **was** often **problematic** for people with families who live here permanently, trying to pay mortgages.*

HT: *Priznali, že **sezónny, neplánovaný charakter** práce **bol** často **problematický** pre ľudí s rodinami, ktorí tu žijú trvale a snažia sa splácať hypotéky.*

SMT: *Uznali, že **sezónne, príležitostná povaha** práce **bolo** často **problematické** pre ľudí s rodinami, ktorí tu žijú trvalo, snažia sa platiť hypotéky.*

NMT: *Uznali, že **sezónny, príležitostný charakter** práce bol často **problematický** pre ľudí s rodinami, ktorí tu žijú trvale a snažia sa platiť hypotéky.*

In the following part, examples of additional frequently occurring errors within the subcategories of *Predicativeness*, as shown in the graph (Figure 2), will be presented. Due to space limitations, errors will be highlighted in bold, without detailed commentaries. It is important to note that some segments may contain other errors beyond those emphasised; however, all errors were thoroughly analysed and assigned to their respective categories. The segments are organised as follows: ST (source text), HT (human translation), SMT (statistical machine translation), and NMT (neural machine translation). In some cases, the error appears in either the SMT or NMT output, or both. Each SMT and NMT segment is marked as either correct or incorrect and can be compared with the HT version for reference.

(2) Example of an error in the category of '*tense*':

ST: *Revenue **has been falling** too, with $4.8bn pulled in last quarter.*

HT: *Aj tržby **klesajú,** v poslednom štvrťroku predstavovali 4,8 miliárd dolárov.*

SMT: *Výnosy **klesá** príliš, s 4,8 mld $ vytiahol v poslednom štvrťroku.* (**correct**)

NMT: *Príjmy tiež **klesali**, keď v poslednom štvrťroku pritiahli 4,8 miliárd dolárov.* (**incorrect**)

(3) Example of an error in the category of '*mood*':

ST: *For more evidence of that theory, **look** to the Mac.*

HT: *Viac dôkazov o tejto teórii **nájdete** na počítači Mac.* (From the point of view of context, comprehensibility, and fluency, it can be considered a correct translation.)

SMT: *Ďalší dôkaz o tom teoreticky **vyzerať** na Mac.* (**incorrect**)

NMT: *Pre viac dôkazov o tejto teórii **sledujte** Mac.* (**correct**)

(4) Example of an error in the category of '*other*' errors:

ST: *The American**'s** manager, Mark Steinberg, delivered added detail on another tale of woe.*

HT: *Američan**ov** manažér Mark Steinberg priniesol ďalšie podrobnosti k ďalšej nešťastnej udalosti.*

SMT: *Americk**ý** manažér, Mark Steinberg, vydal ďalšie podrobnosti o ďalšom príbehu beda.* (**incorrect**)

NMT: *Američan**ov** manažér Mark Steinberg dodal ďalšie detaily ohľadom zlých správ.* (**correct**)

(5) Example of an error in the category of '*incorrect lexeme in the subject part*':

ST: *For one thing, **revenue and unit sales** just keep rising – though from what, and to what, we don't know.*

HT: *Na jednej strane to, že **príjem a jednotkový predaj** stále narastá - hoci nevieme povedať, z čoho a do čoho.*

SMT: *Pre jednu vec, **príjmov a jednotkové predajné** jednoducho stále rastie - aj keď z toho, čo a čo nevieme.* (**incorrect**)

NMT: *Jednak to, že **tržby a jednotkový predaj** stále rastú - aj keď z čoho a do čoho nevieme.* (**correct**)

(6) Example of errors in the category of '*incorrect lexeme in a verb*':

ST: *In other provinces that have adopted western diets you see pretty young girls but when they smile they have rotten teeth, because the sugar **has broken down** their teeth.*

HT: *V iných provinciách, ktoré si osvojili západnú stravu, vidíte pekné mladé dievčatá, ale keď sa usmievajú, majú pokazené zuby, pretože cukor im **pokazil** zuby.*

SMT: *V iných provincií, ktoré prijali západné stravy vidíte celkom mladé dievčatá, ale keď sa usmievajú majú pokazené zuby, pretože cukor **sa pokazil** zuby.* (**incorrect**)

NMT: *V iných provinciách, ktoré si osvojili západnú stravu, vidíte pekné mladé dievčatá, ale keď sa usmievajú, majú zhnité zuby, pretože cukor **si zlomil** zuby.* (**incorrect**)

(7) Example of an error in the category of '*multi-word verbs*':

ST: *Tiger Woods **pulls out** of Dubai Desert Classic with back injury*

HT: *Tiger Woods **odstupuje** pre zranenie chrbta zo súťaže Dubai Desert*

SMT: *Tiger Woods **vytiahne** z Dubai Desert Classic s bolesťami chrbta* (**incorrect**)

NMT: *Tiger Woods **sa sťahuje** z Dubajskej púšte Classic so zranením chrbta* (**correct**)

Figure 2 also includes the results of the *Modal and communication sentence framework*: In the '*category of negation*', 3 errors were recorded in SMT, while no errors were found in NMT.

(8) Example for the category of '*negation*':

ST: *Cadot said **no** explosives **had been found** in the man's bag and there **was** "**no threat**".*

HT: *Cadot povedal, že v pánskej taške **neboli** nájdené **žiadne** výbušniny a že „**neexistuje žiadna hrozba**".*

SMT: *Cadot uviedol žiadne výbušniny boli nájdené v mužovej sáčku a tam bolo „**žiadna hrozba**".* (**incorrect**)

NMT: *Cadot povedal, že v pánskej taške **neboli nájdené žiadne** výbušniny a že „**neexistujú žiadne hrozby**".* (**correct**)

3.2 Syntactic-semantic correlativeness

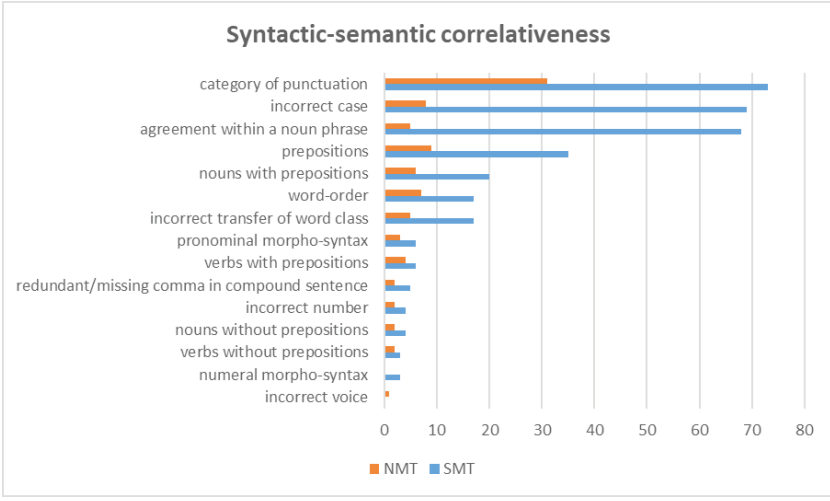

Figure 3: Results in Syntactic-semantic correlativeness for SMT and NMT.

Figure 3 shows the results in the item of *Syntactic-semantic correlativeness*, covering '*nominal morpho-syntax*', '*pronominal morpho-syntax*', '*verbal morpho-syntax*', '*word order*', and '*other issues*'.

SMT numbered the most errors (Figure 3) in the '*category of punctuation*' (SMT 73, NMT 31), '*incorrect case*' (SMT 69, NMT 8), '*agreement within a noun phrase*' (SMT 68, NMT 5). '*Other issues*' in machine translation outputs can be seen in the '*category of prepositions*' (SMT 35, NMT 9), '*nouns with prepositions*' (SMT 20, NMT 6), '*word order*' (SMT 17, NMT 7) and '*incorrect transfer of a word class*' (SMT 17, NMT 5). The categories with the occurrence of errors below 10 are: '*verbs with prepositions*' (SMT 6, NMT 4), '*pronominal morpho-syntax*' (SMT 6, NMT 3),

'*redundant/missing comma in compound sentence*' (SMT 5, NMT 2), '*nouns without prepositions*' (SMT 4, NMT 2), '*incorrect number*' (SMT 4, NMT 2), '*verbs without prepositions*' (SMT 3, NMT 2), '*numeral morpho-syntax*' (SMT 3, NMT 0), and '*incorrect voice*' (SMT 0, NMT 1).

Figure 3 reflects a significant decrease in errors in the category of '*agreement within a noun phrase*', '*incorrect case*', '*prepositions*', and '*punctuation*'; then in '*prepositional phrase*', '*word order*', and '*incorrect transfer of a word class*'. The issue of *Syntactic-semantic correlativeness* is partially connected with the *Predicativeness* in the sense that the category of '*agreement within a noun phrase*' in *Syntactic-semantic correlativeness* is connected with the category of '*agreement in person*', '*number*', '*gender*' in *Predicativeness*. In both cases, nouns are paired with adjectives or other nouns to ensure agreement within a noun phrase (e.g., *English teacher*/*anglický učiteľ*) or to form the genitive construction (e.g., *a teacher of English*/*učiteľ angličtiny*). In both cases, the agreement within noun phrases must be considered. Clearly, this issue relates to other problems recorded in the graph (Figure 3), such as incorrect case or word order.

The use of commas and quotation marks – subject to different norms in English and Slovak – is an error-prone issue within the category of '*punctuation*'. In Slovak, direct speech is marked by a pair of low-high inverted commas (either single or double) („…" or ‚…'). In contrast, English uses common high-high marks (aligning with the top of capital letters) (*'... '* or *"... "*).

The improvement in machine translation between the SMT and NMT is evident even in this category. As shown in example (9), the quotation marks in the NMT output are used correctly:

(9) Example of an error in the category of '*punctuation/quotation marks*':
ST: *The recent reading was described by some experts as* ***"****unimaginable****"****.*
HT: *Nedávne meranie niektorí odborníci označili za* ***„****nepredstaviteľné****"****.*
SMT: *Nedávne čítanie, popísaný niektorými expertmi ako* ***"****nepredstaviteľné****"****.* (**incorrect**)
NMT: *Nedávne čítanie niektorí odborníci označili za* ***„****nepredstaviteľné****"****.* (**correct**)

Other punctuation errors occurred quite frequently following adjuncts in their initial position in sentences.

(10) Example of an error in the category of '*punctuation/commas*':
ST: *At meeting in* ***Bedford, local*** *agricultural business leaders, residents and politicians spoke to home affairs committee MPs about immigration*
HT: *Na stretnutí v* ***Bedforde hovorili*** *lídri miestnych poľnohospodárskych podnikov, obyvatelia a politici s poslancami Výboru pre vnútorné záležitosti o imigrácii*
SMT: *Na stretnutí v* ***Bedfordu, miestne*** *poľnohospodárske Business Leaders, obyvatelia a politici prehovoril k poslancom vnútorné veci o imigrácii* (**incorrect**)

NMT: *Na stretnutí v Bedforde hovorili vedúci miestnych poľnohospodárskych podnikov, obyvatelia a politici s poslancami Výboru pre vnútorné záležitosti o imigrácii* (**correct**)

(11) Example of an error in the category of '*incorrect case*':

ST: *The average selling* ***price of iPads*** *in the last quarter was the same as it was a year ago.*

HT: *Priemerná predajná* ***cena iPadov*** *v poslednom štvrťroku bola rovnaká ako pred rokom.*

SMT: *Priemerná predajná* ***cena iPady*** *v poslednom štvrťroku bol rovnaký ako to bolo pred rokom.* (**incorrect**)

NMT: *Priemerná predajná* ***cena iPadov*** *v poslednom štvrťroku bola rovnaká ako pred rokom.* (**correct**)

Numerous errors occurred in the category '*agreement within a noun phrase*', like in the structure … (*have) so much local food (grown organically)*. In SMT output, the structure which is equivalent to the noun phrase … *(máme) toľko miestne potraviny (pestované organicky)* does not take into account the fact that in Slovak, the expression *toľko* is followed by the genitive case rather than the nominative or accusative. NMT output used the structure with the correct case: … (*máme) toľko* (*ekologicky pestovaných) potravín*, thus the output is comprehensible:

(12)

ST: *It is easy to boil noodles or rice, but they have almost no nutritional value and there is no need to eat imported food when we have* ***so much local food*** *grown organically on our islands.*

HT: *Je ľahké variť rezance alebo ryžu, ale nemajú takmer žiadnu výživovú hodnotu a nie je nutné jesť dovážané potraviny, keď máme na našich ostrovoch* ***toľko*** *ekologicky pestovaných* ***potravín****.*

SMT: *Je ľahké variť rezance alebo ryža, ale nemajú takmer žiadnu výživnú hodnotu a nie je nutné jesť dovážané potraviny, keď máme* ***toľko miestne potraviny*** *pestované organicky na našich ostrovoch.* (**incorrect**)

NMT: *Je ľahké variť rezance alebo ryžu, ale nemajú takmer žiadnu výživnú hodnotu a dovážané jedlo nie je potrebné jesť, keď máme na našich ostrovoch* ***toľko miestnych*** *ekologicky pestovaných* ***potravín****.* (**correct**)

(13) Example of an error in the category of '*prepositions*':

ST: *He* ***talked to*** *Matthew and Danny, feels awful, and he feels terrible for the tournament.*

HT: ***Rozprával sa s*** *Matthewom a Dannym, cíti sa hrozne a cíti sa tak pre turnaj.*

SMT: ***Hovoril Matúša*** *a Danny, cíti strašné, a cíti hrozné na turnaj.* (**incorrect**)

NMT: ***Hovoril s*** *Matthewom a Dannym, je to strašné a pre turnaj sa cíti strašne.* (**correct**)

(14) Example of errors in the category of '*nouns with prepositions*':

ST: *If the labour market was to tighten up we would struggle to fill those seasonal* ***jobs with UK nationals****.*

HT: *Ak by sa mal trh práce sprísniť, snažili by sme sa zaplniť tieto sezónne* ***pracovné miesta občanmi Spojeného kráľovstva.***

SMT: *Ak sa na trhu práce mala sprísniť by sme sa snaží vyplniť tieto sezónne* ***pracovné miesta s britských štátnych príslušníkov.*** (**incorrect** when comparing SMT with HT, **correct** when accepting a possible more word-for-word translation *britskými štátnymi príslušníkmi*)

NMT: *Keby sa trh práce mal sprísniť, usilovali by sme sa obslúžiť tieto sezónne* ***pracovné miesta u občanov Spojeného kráľovstva.*** **(incorrect)**

(15) Example of errors in the category of '*word order*':

ST: *There is no need to eat* ***imported food*** *when we have so much local food grown organically* ***on our islands****.*

HT: *Nie je nutné jesť* ***dovážané potraviny****, keď máme* ***na našich ostrovoch*** *toľko ekologicky pestovaných potravín.*

SMT: *Nie je nutné jesť* ***dovážané potraviny****, keď máme toľko miestne potraviny pestované organicky* ***na našich ostrovoch****.* **(*imported food* – correct, *on our islands* – incorrect)**

NMT: ***Dovážané jedlo*** *nie je potrebné jesť, keď máme* ***na našich ostrovoch*** *toľko ekologicky pestovaných potravín.* **(*imported food* – incorrect, *on our islands* – correct)**

(16) Example of an error in the category of '*incorrect transfer of word class*':

ST: *Yvette Cooper, the committee's* ***chair****, said she wanted to encourage people to talk frankly about immigration.*

HT: ***Predsedníčka*** *výboru Yvette Cooperová uviedla, že chce povzbudiť ľudí k tomu, aby o imigrácii hovorili na rovinu.*

SMT: *Yvette Cooper,* ***predsedá*** *výboru, povedal, že chce, aby sa ľudia otvorene hovoriť o imigrácii.* **(incorrect)**

NMT: ***Predsedníčka*** *výboru Yvette Cooperová povedala, že chce povzbudiť ľudí, aby úprimne hovorili o imigrácii.* **(correct)**

3.3 Compound/complex sentences

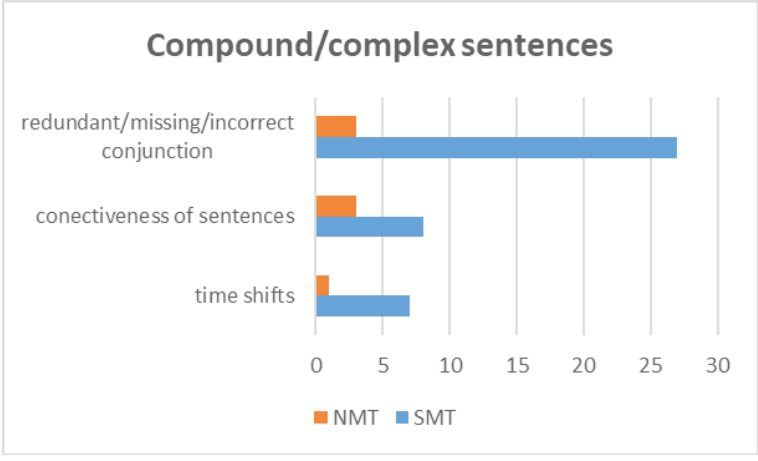

Figure 4: Results of Compound/complex sentences for SMT and NMT.

In the category of *Compound/complex sentences*, the results are like those in the previous category, with more errors recorded in SMT outputs than in NMT outputs (Figure 4). In the category of '*redundant/missing/incorrect conjunction*'

SMT scored 27 errors and NMT 3 errors, in the category of '*connectiveness of sentences*', SMT numbered 8 errors and NMT 3 errors, and in the category of '*time shifts*' in SMT 7 errors and in NMT only 1 error was identified (Figure 4). Overall, there were a few errors in the category of *Compound/complex sentences*, except in the subcategory of '*redundant/missing/incorrect conjunction*'.

One common issue arises from English prepositions, which often have multiple meanings and, consequently, several possible translations into Slovak. For example, the preposition *for* can be translated as *pre*, *ku*, *na*, *po*, or *za*, depending on the context. Selecting the correct equivalent from these options poses a significant challenge for machine translation.

Another issue involves the use of *that* in nominal clauses (which substitute an object or complement), functioning as a complementizer. In informal English, *that* is often omitted, resulting in a *zero that*-clause. Since machine translation tends to follow a more literal rather than free translation approach, if the source text omits *that*, the MT output does as well. This omission can disrupt the structure of the target segment and reduce the overall comprehensibility of the translation.

This issue is illustrated in example (17). Unlike SMT, NMT successfully recognised the omitted relativizer *that* (the category of '*redundant/missing/incorrect conjunction*') and transferred the source sentence correctly:

(17)

ST: *Michel Cadot, the Paris police prefect,* ***said the man*** *had headed towards soldiers "armed with a machete".*

HT: *Prefekt parížskej polície Michel Cadot* ***povedal, že*** *muž smeroval k vojakom „ozbrojený mačetou".*

SMT: *Michel Cadot, Parížska polícia prefekt,* ***povedal muž*** *smeroval k vojakom „vyzbrojených mačetou".* (**incorrect**)

NMT: *Prefekt parížskej polície Michel Cadot* ***povedal, že*** *muž smeruje k vojakom „ozbrojeným mačetou".* (**correct**)

Obviously, other errors concerning different categories are also found here – for example, the use of the verb form *had headed*, which is correctly translated in SMT (*smeroval*) but not in NMT (*smeruje*), or the phrase *armed with a machete*, which is incorrectly rendered in both SMT and NMT (the correct form is *ozbrojený mačetou*). However, as explained above, the examples presented focus primarily on the highlighted category, which in this case is '*redundant/missing/incorrect conjunctions*'.

(18) Example of errors in the category of '*connectiveness of sentences*':

ST: *It hopes individuals will come to the regional meetings to give their views* ***on what*** *approach the government should take to different kinds of migration – skilled to unskilled, students to refugees –* ***and on what steps can be taken to manage*** *the impact of migration in communities.*

HT: *Dúfa, že jednotlivci prídu na regionálne stretnutia, aby vyjadrili svoje názory* ***na to, aký*** *prístup by mala vláda zaujať k rôznym druhom migrácie – od kvalifikovaných k nekvalifikovaným, od študentov k utečencom –* ***a na to, aké kroky môžu podniknúť'*** *na zvládnutie dopadu migrácie na spoločenstvá.*

SMT: *Dúfa, že jednotlivci budú prichádzať do krajských stretnutiach, aby vyjadrili svoj názor* ***na to, čo*** *sa blíži vláda by mala trvať na rôzne druhy migrácie - kvalifikovaných aby nekvalifikovaní, študentov, aby utečencom* ***- a aké kroky možno urobiť'*** *v rámci konania o vplyve migrácie v komunitách.* (***na to, čo*** – **incorrect** connection followed by an incomprehensible structure (the issue is also related to the polysemous word *what*), ***a aké*** *kroky možno urobiť* – **correct** connection)

NMT: *Dúfa, že jednotlivci prídu na regionálne stretnutia, aby predniesli svoje názory* ***na to, aký*** *prístup by mala vláda zaujať k rôznym druhom migrácie - kvalifikovaným a nekvalifikovaným, študentom pre utečencov* ***- a na aké kroky sa môžu podniknúť'*** *na zvládnutie dopadu migrácie na komunity.* (***na to, aký*** – **correct** connection, ***a na aké kroky*** *možno urobiť*– **correct** connection, but followed by an incomprehensible part)

(19) Example of errors in the category of '*time shifts*':

ST: *The French prime minister, Bernard Cazeneuve,* ***said it appeared*** *to be an "attack of terrorist nature".*

HT: *Francúzsky premiér Bernard Cazeneuve* ***povedal, že to vyzerá*** *na „teroristický útok".*

SMT: *Francúzsky premiér Bernard Cazeneuve,* ***že to vyzeralo*** *ako „útok teroristickej povahy".* (**incorrect**)

NMT: *Francúzsky premiér Bernard Cazeneuve* ***uviedol, že sa javil*** *ako „útok teroristickej povahy".* (**incorrect**)

3.4 Lexical semantics

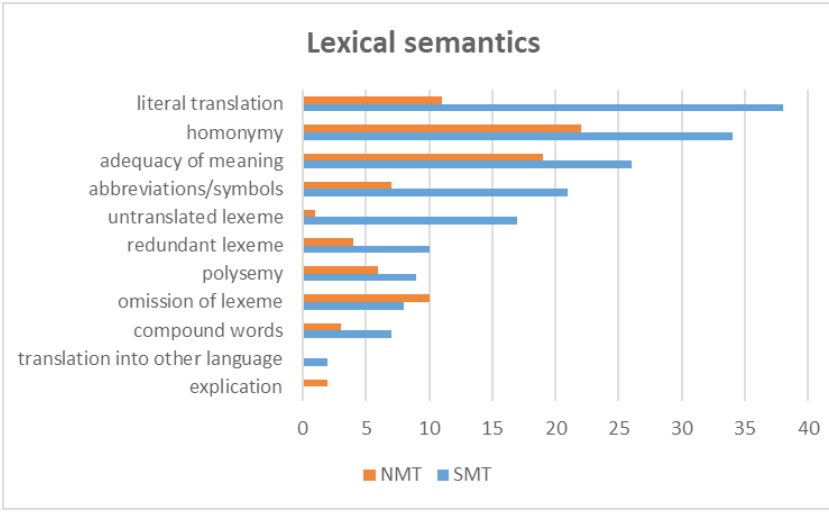

Figure 5: The results in Lexical semantics for SMT and NMT.

In Figure 5, the results from the category *Lexical semantics* for both SMT and NMT are summarized. The highest number of errors was recorded in the following categories: '*literal translation*' (word-for-word translation) (SMT 38, NMT 11), '*homonymy*' (SMT 34, NMT 22), '*adequacy of meaning*' (SMT 26, NMT 19), '*abbreviations/symbols*' (SMT 21, NMT 7), '*untranslated lexeme*' (SMT 17, NMT 1) and '*redundant lexeme*' (SMT 10, NMT 4). In the categories of '*literal translation*' and '*untranslated lexeme*', there is the most significant improvement in NMT, compared to SMT. The other categories reflecting the positive development of machine translation were the following: '*polysemy*' (SMT 9, NMT 6), '*omission of lexeme*' (SMT 8, NMT 10), '*compound words*' (SMT 7, NMT 3), '*translation into other language*' (SMT 2, NMT 0), and '*explication*' (SMT 0, NMT 2) were the categories with a slight increase in errors.

The results in Figure 5 indicate that the most frequent errors in machine translation outputs related to lexical semantics are those connected to '*literal translation*', '*homonymy*', and '*adequacy of meaning*'. These errors stem from the typological differences between English and Slovak. Homonymy is characteristic for languages with a high number of non-derived words (e.g., English), whereas languages with a rich system of word derivation tend to have fewer homonymous words (e.g., Slovak) (see Ondruš – Sabol 1984, pp. 228–229). As a result, both machine and human translators often struggle to find appropriate equivalents for homonymous words, sometimes leading to inadequate translation solutions.

(20) Example of an error in the category of '*literal translation*':
ST: ***Still, serious doubts over the 41-year-old's longevity naturally remain***.
HT: *Stále sa však objavujú vážne obavy nad zotrvaním 41-ročného športovca.*
SMT: ***Napriek tomu vážne pochybnosti nad 41-ročného dlhovekosti prirodzene zostávajú***. (**incorrect**)
NMT: ***Stále*** *však pretrvávajú vážne pochybnosti o dlhovekosti 41 rokov.* (**correct** from the point of view of literal translation, but the expression *o dlhovekosti 41 rokov* has lower comprehensibility. The problem also concerns the meaning of the word *longevity* and the missing reference to its bearer – namely, the sportsman.)

(21) Example of errors in the category of '*homonymy*':
ST: ***May*** *is expected to stay only for the morning session and working lunch.*
HT: *Očakáva sa, že* ***Mayová*** *zostane iba na ranné zasadnutie a pracovný obed.*
SMT: ***Môže*** *sa očakáva, že bude len na dopoludňajšie a pracovným obede.* (**incorrect**)
NMT: *Očakáva sa, že* ***máj*** *zostane iba na ranné zasadnutie a pracovný obed.* (**incorrect**)

(22) Example of an error in the category of '*adequacy of meaning*':
ST: *One soldier was slightly wounded, and another soldier fired back five* ***shots***.
HT: *Jeden vojak bol ľahko zranený a ďalší vojak naspäť vystrelil päť* ***rán***.
SMT: *Jeden vojak bol ľahko zranený a ďalší vojak vypálil päť* ***striel***. (**correct**)
NMT: *Jeden vojak bol ľahko zranený a ďalší vojak vystrelil päť* ***záberov***. (**incorrect**)

(23) Example of errors in the category of '*abbreviations*':

ST: *The estimated cost of decommissioning the plant and decontaminating the surrounding area had risen to 21.5**tn** yen (£150**bn**), nearly double an estimate released in 2016.*

HT: *Odhadované náklady na vyradenie elektrárne z prevádzky a na dekontamináciu okolia sa zvýšili na 21,5 **biliónov** jenov (150 **miliárd** GBP), čo je takmer dvojnásobok odhadu zverejneného v roku 2016.*

SMT: *Odhadované náklady na odstavenie elektrárne a dekontamináciu okolia stúplo na 21.5**tn** jenov (150 **miliárd** Sk), takmer dvojnásobným odhadu vydaná v roku 2016.* (*tn – tn* untranslated abbreviation, *bn – miliárd* **correct**)

NMT: *Odhadované náklady na vyradenie elektrárne z prevádzky a na dekontamináciu okolia sa zvýšili na 21,5 **miliárd** jenov (150 **miliárd** GBP), čo je takmer dvojnásobok odhadu zverejneného v roku 2016.* (*tn – miliárd* is **incorrect**, *bn – miliárd* is **correct**)

(24) Example of an error in the category of '*untranslated lexeme*':

ST: *A **spokeswoman** for the Louvre said the museum was "closed for the moment".*

HT: ***Hovorkyňa** Louvru uviedla, že múzeum je momentálne zatvorené.*

SMT: ***Spokewoman** pre Louvre povedal, že múzeum bolo „uzavretý pre túto chvíľu".* (**incorrect**)

NMT: ***Hovorkyňa** Louvru uviedla, že múzeum bolo „momentálne uzavreté".* (**correct**)

(25) Example of errors in the category of '*polysemy*':

ST: *The **shooting** comes with France on its highest state of alert with thousands of troops patrolling the streets following a string of attacks in the last few years.*

HT: ***Streľba** prichádza v čase, keď je Francúzsko v stave najvyššej pohotovosti, pričom po sérii útokov v posledných rokoch hliadkujú v uliciach tisíce vojakov.*

SMT: ***Natáčanie** je dodávaný s Francúzskom na jeho najvyššom stave pohotovosti s tisíckami vojakov hliadkujúci v uliciach po reťazec útokov v posledných niekoľkých rokoch.* (**incorrect**)

NMT: ***Natáčanie** prichádza s Francúzskom na najvyššom stupni pohotovosti, keď tisíce vojakov hliadkujú po uliciach po niekoľkých útokoch v posledných rokoch.* (**incorrect**)

(26) Example of an error in the category of '*omission of lexeme*':

ST: *Then there's the red-headed **stepchild** of the Apple revenue streams.*

HT: *Potom je tu ešte „ryšavé" **nevlastné dieťa** zdrojov príjmov spoločnosti Apple.*

SMT: *Potom je tu hrdzavý nevlastní zdroje príjmov Apple.* (**incorrect**)

NMT: *Potom je tu **nevlastná dcéra** tokov výnosov spoločnosti Apple.* (**correct**, maybe more adequate translation would be *nevlastné dieťa*)

(27) Example of an error in the category of '*compound words*':

ST: *Paris **anti-terrorist** police are investigating after a man carrying a rucksack wounded one soldier with a knife.*

HT: *Parížska **protiteroristická** polícia vyšetruje prípad, keď muž s batohom zranil vojaka nožom.*

SMT: *Paríž **anti-teroristickej** polícia vyšetruje po tom, čo muž niesol batoh zranené jedného vojaka s nožom.* (**incorrect**)

NMT: *Parížska **protiteroristická** polícia vyšetruje, keď muž, ktorý nosil ruksak, zranil jedného vojaka nožom.* (**correct**)

4. DISCUSSION AND CONCLUSIONS

Our goal was to analyse the developments and improvements of NMT compared to SMT by identifying and classifying the differences in their outputs. We focused on typological differences between the two languages – English, primarily an analytic language, and Slovak, primarily a synthetic language – within newspaper texts.

To evaluate these differences, we derived from Vaňko's (2017, pp. 83–100) categorical framework for evaluating MT errors, which provides a more detailed analysis of morpho-syntactic and syntactic-semantic relations, the areas where significant errors occur in the Slovak language. The quality of SMT and NMT outputs was analysed using a sample of newspaper articles from the British online newspaper *The Guardian*. Newspaper texts are frequently translated by MT systems due to their broad vocabulary and diverse range of topics.

Based on the results, NMT performed significantly better in terms of translation fluency, adequacy, and accuracy. Its output was more natural, clear, and comprehensible compared to SMT. However, NMT is not flawless – it still has certain shortcomings that require correction by a human post-editor. Numerous errors occurred in the category of *Syntactic-semantic correlativeness* (namely in the category of '*punctuation*', '*incorrect case*', '*agreement within a noun phrase*' and in the category of *Lexical semantics* ('*literal translation*', '*homonymy*', '*adequacy of meaning*', '*abbreviations/symbols*', and '*untranslated lexeme*'). Surprisingly, the category of '*omission of lexeme*' recorded more errors in NMT output than in SMT output. This finding supports previous research (see Bentivogli et al. 2016; Munková 2017, p. 23), which indicates that NMT outputs tend to be more fluent than those produced by phrase-based SMT. While NMT reduces literal translations and improves fluency, this often comes at the expense of adequacy. NMT sometimes produces unexpected translation solutions, generating sentences that appear fluent but lack semantic accuracy. These results are aligned with the findings of Petráš and Munková (2023, p. 87), which suggest that present NMT is more successful in translating longer and more complex syntactic structures. However, while the translation may appear fluent, its adequacy remains questionable (see Welnitzová 2023).

The detected errors in *Syntactic-semantic correlativeness* and *Lexical semantics* correspond to the typological differences between English and Slovak, as well as the nature of the examined texts. As newspaper texts are characterised by a high occurrence of nouns in various forms (e.g., nouns as pre-modifiers, post-modifiers, and within noun phrases), issues related to nouns are both frequent and significant. The category of nominalisation, then prepositional phrases after nouns, and attributive adjectives are common features of newspaper style, further contributing to translation challenges. Based on this, noun-related issues are both frequent and significant in terms of comprehensibility.

Despite persisting errors – primarily in *Syntactic-semantic correlativeness* and *Lexical semantics* – NMT has shown significant improvements. Unlike SMT, which uses a more word-by-word approach, NMT translates a sentence as a whole, leading to more fluent and comprehensible translations. However, challenges remain at the lexical level, particularly due to rich homonymy in English and the issues in adequacy. Other notable issues include literal translation and omission of lexemes, which continue to affect translation accuracy. These challenges present potential areas for future research and further advancements in machine translation.

In this context, Pondelíková and Luprichová (2024, p. 198) claim that AI-powered tools are not only transforming the way translations are performed but also reshaping the broader field of language and literacy. Moreover, the use of AI tools can significantly contribute to the improvement of users' linguistic and cognitive abilities, suggesting that AI can play an important role not only in education but also in translation practice. Absolon (2024, p. 9) predicts the decline in translation and localisation firm revenue losses due to the impact of AI, particularly the rise of large language models, which extend beyond translation services to other linguistic domains such as terminology management, research, and more.

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Resumé

PRETRVÁVAJÚCE GRAMATICKÉ CHYBY STROJOVÉHO PREKLADU

Článok sa zaoberá problematikou gramatických chýb vo výstupoch strojového prekladu (SP) a hodnotí kvalitu dvoch prístupov: štatistického SP (SMT – Statistical Machine Translation) a neurónového SP (NMT – Neural Machine Translation). Výskum porovnáva kvalitu výstupov strojových prekladov v smere angličtina – slovenčina a zameriava sa na rozdiely medzi danými typologicky rozdielnymi jazykmi (angličtina klasifikovaná zväčša ako analytický jazyk a slovenčina ako syntetický jazyk).

Kvalitu SP sme hodnotili na vzorke publicistických textov vyexcerpovaných z britského denníka *The Guardian*. Texty sme dali preložiť strojovému prekladaču Google Translate pri dvoch rozdielnych prístupoch (SMT a NMT), ktoré následne posteditovali dvaja ľudskí prekladatelia v prostredí OSTEPERE (systém na hodnotenie, preklad a post-editáciu SP). Výstupy strojového prekladu analyzovali odborníci na slovenský jazyk, ktorí identifikovali a klasifikovali chyby v jednotlivých gramatických kategóriách.

Výsledky výskumu ukázali, že neurónový strojový preklad (NMT) možno považovať za oveľa kvalitnejší ako štatistický strojový preklad (SMT) v takmer všetkých hodnotených kategóriách. Preklad prostredníctvom NMT je plynulejší, prirodzenejší a zrozumiteľnejší. Pri preklade strojový prekladač pracuje s vetou ako s celkom a nie ako s jej časťami (frázami), ako to bolo v prípade SMT. Najvýraznejšie zlepšenie sme zaznamenali v kategórii predikatívnosti, v ktorej NMT dosahuje výrazne lepšie výsledky napr. v zhode medzi podmetom a prísudkom, a to v osobe, čísle a rode. V kategórii predikatívnosti sa znížila početnosť chýb aj pri nekorektnom používaní času a rodu.

Ďalšou významnou kategóriou, v ktorej NMT preukázal zlepšenie, je syntakticko-sémantická korelácia. V tejto oblasti sa znížil počet chýb v interpunkcii, zhode a väzbe a v neposlednom rade aj slovoslede. Typologické rozdiely medzi angličtinou a slovenčinou – najmä v oblasti syntaktickej flexibility a morfologických zmien – predstavujú pre strojový preklad výraznú výzvu. Anglický jazyk ako analytický jazyk definuje zväčša pevný slovosled, no pre slovenský jazyk je typický slovosled voľnejší. NMT dokáže tieto rozdielne charakteristiky

lepšie uplatňovať, a preto výstupy strojového prekladu pôsobia zrozumiteľnejšie a prirodzenejšie.

Problémy SP pretrvávajú v oblasti lexikálnej sémantiky, najmä pokiaľ ide o polysémiu, homonymiu a adekvátny transfer významu slova. Výsledky výskumu ukázali, že hoci sa pri NMT v porovnaní so SMT znížil počet tzv. doslovných prekladov, NMT nie je spoľahlivý pri výbere lexém v komplexnejších vetných štruktúrach, čo môže negatívne ovplyvniť celkový význam vety ako celku. Daný fakt potvrdzuje potrebu post-editácie výstupu SP ľudským prekladateľom alebo posteditorom, ktorý zabezpečí korekciu chýb a nepresností.

Napriek tomu, že neurónový strojový preklad (NMT) predstavuje v porovnaní so svojím predchodcom štatistickým strojovým prekladom (SMT) výrazné zlepšenie, gramatické chyby pretrvávajú. Výsledky výskumu zároveň potvrdzujú, že technologický pokrok v oblasti strojového prekladu neustále zlepšuje kvalitu strojového prekladu, a tým sa postupne zmenšuje rozdiel medzi kvalitou strojového a ľudského prekladu. Odborníci na SP vkladajú nádeje do vývoja hĺbkového učenia a umelej inteligencie, ktoré by mohli odstrániť aj v súčasnosti pretrvávajúce problémy a zvýšiť spoľahlivosť prekladov aj pri jazykovo rozdielnych jazykoch, akými sú angličtina a slovenčina.