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Contrastive study of lexical cohesive devices in chemical engineering papers in English and Serbian

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Abstract

This study aims to conduct a contrastive analysis of the use of lexical cohesive devices in research articles written in English and in Serbian. The analysis was conducted on a sample of twenty abstracts of English and Serbian research articles in the field of chemical engineering. The model taken as the framework for this analysis was the one proposed by Halliday and Hasan (1976), which describes six types of lexical cohesive devices, namely the use of repetition, synonyms (including hyponyms), superordinates, general words and collocations. The results revealed that Serbian texts rely more on lexical cohesion in achieving coherence since Serbian abstracts had a significantly higher density of total lexical cohesive devices compared to those written in English. Every subcategory of lexical cohesive devices also had greater density in Serbian abstracts compared to English abstracts, with the smallest difference present in repetitions. The use of superordinates was, however, significantly higher in Serbian texts. The two corpora had the same distribution of individual reiteration subtypes, with the highest percentage of repetition, followed by synonymy, and then superordinates. The results obtained highlight the need for non-native English authors to master the various strategies of English scientific writing, ensuring greater coherence and readability of research paper abstracts, and effectiveness in academic communication.

Keywords: lexical cohesion, discourse analysis, contrastive analysis, academic writing, research paper abstracts, chemical engineering

1. INTRODUCTION

Research articles have become the focus of the prolific investigations in the field of academic discourse for the last couple of decades. As one of the major media for research communication, the growing attention they have been receiving is a consequence of the growing intensity of academic exchange on a global scale. The majority of studies use the genre analysis approach, which offers a framework for different research directions and perspectives, from simple descriptions of the functional style characteristics, to analyses of lexical specificities, syntactic structure specificities, genre variations, to identifying thematic and rhetoric patterns and exploring metadiscourse variations across different disciplines, or different cultural contexts. This particular genre of academic discourse typically consists of several distinct parts or sub-genres, each with a specific, well-defined purpose and specific organization (Bhatia 1993; Dudley-Evans 1997; Swales 1990).

Among these integral parts, research article abstracts have emerged as a well-established genre in academic discourse. Research article abstracts are of major importance in disseminating findings in academic research by offering a short account or a concise summary of research findings, or the "article synopsis" (Bhatia 1993), which is reflected in their specific micro-organization incorporating moves such as purpose, methodology, results and conclusions. However, apart from providing a brief overview, they also have a number of other important functions such as engaging potential readers, allowing them to make a quick assessment of the relevance and scope of the full text and decide whether to engage with it further (Hyland 2006; Yakhontova 2003). They are, therefore, considered a powerful rhetorical medium that directly affects the re-

ception with the audience and shapes academic communication.

Studies of research article abstracts also offer many different perspectives using genre analysis as their starting point. Many studies focus on the variations in the rhetorical structure of research abstracts both within and across disciplines (Bhatia 1993; Huckin 2001; Hyland 2000; Melander, Swales, & Fredrickson 1997). On the other hand, numerous investigations of research abstracts are based on the notion that the conventions for the organization of thought and argument are language- or culture-specific. These cross-cultural studies mainly involve contrastive analyses of the variations in the academic writing style. Contrasting English with Slavic academic writing traditions has proved that academics from Slavic cultural backgrounds share certain similar tendencies towards indirectness, digressions, and associativeness (Blagojević 2015). A number of studies has been conducted giving considerable insight into the differences between English and Serbian academic writing. Blagojević (2014) investigated the differences between the rhetorical moves English and Serbian conference abstracts and reported a less uniform rhetorical structure of Serbian abstracts compared to their English counterparts. Dževerdanović-Pejović (2015) focused on the differences and similarities between the Montenegrin and the Anglo-Saxon discourse and rhetorical practices using a sample of linguistic abstracts, and the analysis has shown that the structure of the English abstracts was far more organized in terms of discerning moves and steps at the level of the macro-structure.

Cohesion and coherence are essential for making a text engaging and consistent, and they are often considered key indicators of writing or speaking quality. Exploring the differences and similarities in the ways in which cohesive ties are used in text formation in academic writing in different cultures may therefore help non-native English researchers develop their writing skills, communicate their findings effectively and increase the visibility of their work. Halliday and Hasan (1976) offered a detailed description of the model for the analysis of cohesion in a text. Cohesive relations are regarded as resources that English has for creating texture, or the quality of being a text. They maintain that the unity of a text differs from the structural integration among the parts of a sentence or a clause. Cohesion thus goes beyond the range of structural relations and is achieved through semantic relations. Semantic relations and cohesion, according to Halliday's systemic functional linguistics, reflect the stratal nature of the organization of language, in which the semantic system is realized by/as the lexicogrammatical system (or grammar and vocabulary), and the lexicogrammatical system is, in turn, realized by/as the phonological and phonetic systems. The authors therefore divide cohesive devices into two broad categories: grammatical cohesion and lexical cohesion. While grammatical cohesion is achieved through reference, substitution, ellipsis and conjunction, lexical cohesion is a part of vocabulary system and is realized through semantic relationships among lexical items.

In this framework, the focus is on the intersentence cohesion, and cohesion is "interpreted, in practice, as the set of semantic resources for linking a SENTENCE with what has gone before (Halliday & Hasan 1976). Authors explain that any grammatical unit –whether that be a sentence, a clause, a phrase, or a word, etc. – contributes to the unity of the text or the texture, and these are internally cohesive simply because they are connected by structural relations. However, the term cohesion as used by Halliday and Hasan refers to non-structural text forming relations that go beyond sentence boundaries. These cohesive relations between sentences are important because they are the only source of texture, and are what distinguishes one text from the other. We have based our analysis on the cohesive ties that occur between sentences for the purpose of this study.

1.1. Lexical cohesion

Lexical cohesion is an important factor in achieving coherence for many reasons. As pointed out by Halliday and Hasan (1976), the cohesive effect of lexical cohesion is achieved by the continuity of lexical meaning, i.e. lexical items themselves may be connected through semantic relations (synonymy, hyponymy, metonymy), or through purely lexical relations, or the tendencies of certain lexical items to occur frequently together in a range of common environments (collocation). In order to achieve cohesion, lexical items entering into cohesive relations do not depend on the relation of reference, that is, they do not have to have the identical referent.

Although lexical cohesive devices carry no obvious signals of their cohesive functions, and they are more difficult to identify compared to grammatical cohesive devices, they, nevertheless, play an important part in organizing texts. According to Hyland (2006), grammatical cohesive devices like replacement and pronouns are rarely used in scientific texts, whereas lexical cohesive devices have a "high lexical density". The awareness of lexical cohesive devices becomes even more important due to the fact that they are major factors contributing to the coherence and texture of academic writing, ensuring a clear and effective communication with the audience.

In the 1976 work *Cohesion in English*, Halliday and Hasan suggested the framework for the description of lexical cohesion which first included two main categories,

reiteration and collocation. Reiteration can further be expressed as the same word (repetition), synonym (or near-synonym), superordinate, and general world. This classification was later revised by Hasan in her work called *Coherence and Cohesive Harmony* Hasan (1984), where two new categories of lexical devices were introduced – general and instantial. General cohesive devices include repetition, synonymy, antonymy, hyponymy and meronymy, whereas instantial cohesion includes equivalence, naming and semblance. Various new and modified models of lexical cohesion have been introduced over the several past decades, most notably (Hoey 1991; Martin 1992; McCarthy 1991; Morris & Hirst 1991; Taboada 2004; Tanskanen 2006), etc. Although these revised versions and modified models have gained significant attention, Halliday and Hasan's original model from 1976 is still used as the framework for much of the research in this area of linguistics.

This study investigates two main issues. Firstly, it aims to identify the types of cohesive devices used in abstracts written in English and Serbian. The second goal is to calculate the density of lexical cohesive devices employed. The study examines whether there are differences in the type, frequency, and use of these devices between the two corpora in the field of chemical engineering. The motivation behind this study is to give an insight into the areas where potential differences in writing practice between the two cultural backgrounds may affect the way in which non-native English authors present their research in English.

2. METHODOLOGY

In order to explore the differences in the use of lexical cohesive devices in the abstracts of research articles in the field of chemical engineering, a qualitative study was conducted on a sample of 20 research article abstracts randomly chosen from different areas of chemical engineering and technology. The English corpus (RPAE) comprised 10 articles from various journals in the field of chemistry and chemical engineering, namely: *Chemical Engineering Research and Design, Chemical Engineering Science, Journal of Catalysis, Metabolic Engineering Communications*, and *Chemical Engineering Journal*. The total number of sentences in the RPAE corpus was 92, which on the average is of 9.2 sentences per abstract. However, the length of abstracts varied from the longest abstract of 16 sentences to the shortest abstract which had only 5 sentences. The total number of words used was 2280, which means that the average sentence length was 24.78 words per sentence.

The research articles that served as a source for the analysis of Serbian abstracts were collected from the prestigious Serbian journal in the field of chemical engineering, namely *Hemijska industrija*. The ten articles chosen comprised the second corpus which we called RPAS. The total number of sentences used was 81, or 8.1 sentence per abstract on average, with the longest abstract of 11 sentences and the shortest of 5 sentences. A total of 1701 words were used or 21 words per sentence on average.

Tables 1 and 2 give an overview of the two corpora in terms of the articles used and the statistics on the number of sentences and words per abstract.

This study aimed to examine whether there are differences in the type, frequency, and use of lexical cohesive devices between the two corpora. The analysis first involved identifying the classes of lexical cohesive devices present in the abstracts of each corpus. Their occurrences were recorded as frequencies. These values were then converted into densities per 10,000 words in order to facilitate comparison between the two corpora. For the purpose of this study, the analysis of the cohesive ties included exclusively those that occur between sentences (see Introduction, p. 2).

The abstracts were analyzed based on the model of Halliday and Hasan (1976) for the analysis which proposes the following taxonomy of cohesive devices:

2.1. Repetition

The most straightforward class of reiteration is repetition. It mainly involves reusing the same lexical item in the identical form or as a close variant with a simple grammatical change, which would be characterized as simple repetition (e.g. a *mushroom – the mushroom, a mushroom – mushrooms, study – studying, study – studied*, etc.). Complex repetition involves a significant change, which may be either a change in the grammatical functions of the same lexical items (e.g. *works,* noun plural – *works,* verb, present form) or the items are not identical but share the same content morpheme (e.g. *cultural determinism – cultural determinist*

2.2. Synonymy

Lexical cohesion is also achieved by reiterating the meaning of one lexical item when choosing a word which is synonymous with it or which is a near synonym (e.g. *examination – investigation, to study – to research, the ascent – the climb, people – the public.*

2.3. Superordinate

This type of reiteration involves the relation between an item and a more general, or superordinate item. It can

Table 1. English Corpus (RPAE) Statistics

Abstract No.	Sentence Count	Word Count	Average Sentence Length
RPAE1	8	210	26.25
RPAE2	9	231	25.66
RPAE3	16	381	23.82
RPAE4	7	147	21
RPAE5	5	172	34.4
RPAE6	9	218	24.22
RPAE7	11	267	24.27
RPAE8	10	204	20.4
RPAE9	8	185	23.13
RPAE10	9	265	29.44
Total	**92**	**2280**	**24.78**

Table 2. Serbian Corpus (RPAS) Statistics

Abstract No.	Sentence Count	Word Count	Average Sentence Length
RPAS1	8	139	17.38
RPAS2	9	177	19.67
RPAS3	8	191	23.88
RPAS4	11	209	19.00
RPAS5	5	99	19.80
RPAS6	7	111	15.86
RPAS7	7	168	24.00
RPAS8	9	206	22.89
RPAS9	8	184	23.00
RPAS10	9	217	24.11
Total	**81**	**1701**	**21**

be referred to as the relation between the specific and the general, or the relation in which the meaning of one item is included in the meaning of the other item. For example, *the ascent – the task, the boy – the child, car – vehicle*, etc.

2.4. General item

As their name suggests, general items or nouns refer to only a small set of nouns with generalized reference. These form cohesive ties by referencing previously mentioned lexical items in a broad, generalized way. Their meanings are defined by major semantic features such as "human noun", "non-human animate", "inanimate, concrete countable", "action", "place", etc. Therefore, examples include words such as *person, creature, thing, move, place*, etc. Halliday and Hasan propose that these nouns lie on the borderline between grammatical and lexical cohesion inasmuch as they are a closed system. Moreover, unlike other subclasses of reiteration in which identity of reference is irrelevant, instances of the general noun are only cohesive if identity of reference is involved Halliday and Hasan (1976).

2.5. Collocation

The category of collocation is by far the most ambiguous and debatable category of lexical cohesion. Halliday and Hasan (1976) define collocation as the type of "cohesion that is achieved through the association of lexical items that regularly co-occur". Collocations involve, therefore, different types of lexicosemantic relations, namely, pairs of opposites (complementaries, e.g. *boy – girl*; antonyms, e.g. *like – hate*; converses, e.g. *order – obey*), pairs of words drawn from an ordered series (e.g. *Monday – Tuesday*), unordered lexical sets (e.g. *basement – roof*), meronyms and co-meronyms (e.g. *mouth – head, mouth – nose*), as well as co-hyponyms (*e.g. chair – table,* both co-hyponyms of *furniture*). Collocation also includes the instances in which pairs of lexical items are in some way associated with each other in language, but the semantic relation is not of a systematic nature. Here the cohesive effect is achieved through the tendency to co-occur in proximity.

Table 3. The Use of Lexical Cohesive Devices (LCDs) in the English Corpus (RPAEC)

RPAEC	Repetition	Synonym	Superordinate	General Word	Total Reiteration	Collocation	Total
Frequency	379	205	33	-	617	492	1109
Density per 10,000 words	1662.28	899.12	144.74	-	2706.14	2157.89	4864.04
Percentage in total LCD (%)	34.17	18.85	2.98	-	55.64	44.36	100

3. RESULTS AND DISCUSSION

This section focuses on the quantitative analysis of the use of lexical cohesive devices in the abstracts of research papers in the field of chemical engineering and technology and the comparison between the two corpora, namely the corpus containing research articles written in English and the corpus containing research papers in Serbian. The results of the analysis are shown in Tables 1-7.

3.1. English Corpus

The abstracts written in the English language contained a total of 1109 instances of lexical cohesive ties, as shown in Table 3, where this figure is represented as a measure of frequency. In order to be able to achieve a more accurate description of the use of cohesive ties in this type of discourse and to be able to compare it across different corpora, a measure of density per 10,000 words was calculated, based on the total number of words used in abstracts. The results showed that the overall density of lexical cohesive devices used per 10,000 words was 4864.04, or 48.64%.

The frequency of overall reiterative devices was reasonably higher than the frequency of collocation, with 617 occurrences of reiteration compared to 492 instances of collocation. This means that the density ratio between reiteration and collocation was 2706.14 to 2157.89 instances per 10,000, i.e., 27.06% to 21.57%.

Among the reiteration subtypes, the most frequently used was repetition with 379 occurrences, or 1662.28 density, then synonymy with 205 instances and the density of 899.12, whereas only 33 instances of superordinates were found (144.74 per 10,000 words). No instances of general word appeared in the investigated sample.

Writers in English thus used an average of 47.71 lexical cohesive device per abstract calculated by averaging the values of density for each abstract individually (frequency/abstract word count × 10,000).

3.2. Serbian Corpus

The results of the analysis showed that Serbian writers used a total of 1052 lexical cohesive devices, which gives a density of 6184.60 occurrence of lexical cohesive device per 10,000 words (Table 4), i.e., 61.85%. The ratio between the two main categories of reiteration and collocation in frequency is 567 to 485, and 3333.33 to 2851.26 in density per 10,000 words.

A detailed analysis of reiteration showed that the highest frequency was observed in the subcategory of repetition, namely a frequency of 297 and density of 1746.03 cohesive ties per 10,000 words. The next most frequently used subcategory was synonymy, with 178 occurrences and the density of 1046.44. Serbian authors used a total of 92 superordinates (540.86 occurrences per 10,000 words), and no general words were observed.

The average density per 10,000 words for each abstract written in Serbian individually (frequency/abstract word count per abstract × 10,000) was calculated to be 59.8.

It can be seen that, although the English corpus contained a higher overall frequency compared to the Serbian corpus, the density per 10,000 words was higher in the Serbian sample due to the lower overall word count of the Serbian corpus, namely 6184.60 for RPAS to 4864.04 for RPAE. This also means that the Serbian abstracts exhibited a higher density of lexical cohesive devices per abstract, i.e. 59.8 for RPAS to 47.71 in RPAE.

The two corpora had the same distribution of individual reiteration subtypes, with the highest percentage of repetition, followed by synonymy, and then superordinates. Neither of the corpora contained examples of the general word. However, English abstracts had a slightly higher tendency towards repetition, with 61.43% of occurrences of repetition out of all reiteration cases. Synonyms represented 33.23% of total reiteration, whereas the number of superordinates was relatively small, only 5.34%. Although the classes of reiteration found were distributed in the same order in the Serbian corpus, the differences between the frequencies were considerably smaller, with the cases of repetition counting for 52.38%, synonyms 31.39%, whereas superordinates represented 16.22% of total reiteration examples. English scientific articles tend to be more reader-oriented compared to their Slavic counterparts Yakhtonova (2002), which means that the linguistic means that serve to engage the reader may be more varied. For example, Cvijetinović (2019) re-

Table 4. The Use of Lexical Cohesive Devices (LCDs) in the Serbian Corpus (RPASC)

RPASC	Repetition	Synonym	Superordinate	General Word	Total Reiteration	Collocation	Total
Frequency	297	178	92	-	567	485	1052
Density per 10,000 words	1746.03	1046.44	540.86	-	3333.33	2851.26	6184.60
Percentage in total LCD (%)	28.23	16.92	8.75	-	53.89	46.10	100

Table 5. The Use of Two Main Subtypes of LCDs in the Corpora

Corpus	Reiteration		Collocation		Total LCD	
	Frequency	Density per 10,000 words	Frequency	Density per 10,000 words	Frequency	Density per 10,000 words
RPAEC	617	2794.38	492	2228.26	1109	4864.04
RPASC	567	3333.33	485	2851.26	1052	6184.60

Table 6. The Use of Reiterative LCDs in the Corpora

Corpus	Reiteration								Total Reiteration	
	Repetition		Synonym		Superordinate		General Word			
	Freq.	Density	Freq.	Density	Freq.	Density	Freq.	Density	Freq.	Density
RPAEC	379	1662.28	205	899.12	33	144.74	-	-	617	2706.14
RPASC	297	1746.03	178	1046.44	92	540.86	-	-	567	3333.33

Table 7. The use of collocations in the corpora

Corpus	COLLOCATION	
	Frequency	Density per 10,000 words
RPAEC	492	2228.26
RPASC	485	2851.26

ported that adverbial discourse markers were significantly more frequently used in English chemical engineering papers compared to those written in Serbian.

4. CONCLUSION

The findings of this study indicate that the Serbian abstracts had a significantly higher density of total lexical cohesive devices compared to those written in English. Every subcategory of lexical cohesive devices also had greater density in Serbian abstract compared to English abstracts, with the smallest difference present in simple repetitions, whereas superordinates had almost triple the density in Serbian abstracts. This means that Serbian texts rely more heavily on lexical cohesion as the means of achieving cohesion and coherence. The reason for this may lie in the fact that the abstract is a short written form, designed to give a concise account of complex research, and, consequently, balance brevity with informativeness. Lexical words and lexical cohesive devices are, therefore, major factors in communicating meaning and are indispensable in any academic writing tradition. On the other hand, English scientific articles tend to be more reader-oriented compared to their Slavic counterparts which means that the linguistic means that serve to engage the reader may be more varied.

The results of this study showed that the two corpora were similar in the distribution of individual subclasses of LC devices. The most frequently used devices in both corpora were collocations, then instances of repetition, followed by synonyms and, lastly, superordinates. The ratio between two major categories of reiteration and collocation was also similar, with collocations having only slightly lower densities than reiteration instances.

Considering the fact that there are considerable differences in the use of lexical cohesive devices, it can be concluded that non-native English authors with Serbian cultural and linguistic background could benefit from mastering all the various strategies of English scientific

writing, ensuring greater coherence, readability, and effectiveness in presenting their research results. It is also worth noting that he research conducted for this purpose involved only a small sample of research paper abstracts in a small niche of chemical engineering and technology. Given the complexity of academic discourse across different disciplines, sciences and cultures, there is certainly need for further research that would give insight into these intricacies.

APPENDIX

Corpora

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