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## A CORPUS-DRIVEN ANALYSIS OF LEXICAL BUNDLES IN MEDICAL RESEARCH ARTICLES WITH A VIEW TO EVALUATING EDITING EFFECTS

### Abstract

Lexical bundles (LBs), as building blocks of fluent academic language production, have been studied extensively, but less attention has been paid to non-native authors' productions. Nor has there been a study to investigate the possible changes that LBs might undergo in non-native authors' productions when submitted to copy editors. Therefore, a 914,666-word corpus was selected, encompassing both edited and unedited articles in medical sciences written by Persian academics. Then, we studied the frequency of 4-word bundles alongside their structural and functional features, as well as the changes the editing process could bring about in this regard. The results indicated that although types and tokens of bundles generally increased by 6.6% and 17.3% respectively after the editing process, this increase did not include all subcategories. Furthermore, the editing process was not found to make any tangible structural or functional modifications. Pedagogically, our findings could have implications for non-native authors and editors.

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### Key words

English for academic purposes (EAP), lexical bundles, editing, academic writing, corpus-based analysis, medical research articles.

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## 1. INTRODUCTION

Research articles (RAs) are considered the most important channel for presenting new knowledge in today's scientific arena. However, the influx of RA authors from diverse linguistic, educational, and cultural backgrounds poses a challenge, as they may lack the necessary academic literacy skills within their chosen disciplines (Orfanò & Wingate, 2024). In order to hone their skills in producing high quality articles, besides the general language proficiency (Skelton & Richards, 2021), academics need to become aware of certain rhetorical and linguistic conventions often employed for effective communication. Formulaic word sequences or "prefabricated chunks, fixed, or semi-fixed expressions" (Howarth, 1998, p. 24) are considered crucial in academic writing, and a major differentiating trait of specific modes, registers, and genres (Hyland & Jiang, 2018). The skillful use of such lexical strings demonstrates an academic author's linguistic competency and writing ability (Wei & Lei, 2011), potentially earning them recognition within their discourse community (Salazar, 2014).

Given the importance of lexical bundles (LBs) in academic writing, the need for non-native English speaker (NNS) authors to master them has been frequently highlighted. Hyland (2016) notes, there is a widespread view in the field of English for Research Publication Purposes (ERPP) that "EAL (English as an Additional Language) scholars are disadvantaged in the competitive world of academic publishing by virtue of their status as second language writers" (p. 10). Perhaps that is why NNS writers are increasingly obliged to submit their manuscripts to be reviewed and edited by experts (see Carlsson et al., 2024).

Actually, this handicap may manifest itself more tacitly hindering NNS authors' ability to truly excel in their fields. For instance, in the study conducted by Sedghi et al. (2020), it was found that even the recent boom in Iranian scientific output is overshadowed by the concerning trend that the rise in the number of publications is actually taking place in local journals categorized within the lower Q3 and Q4 rankings of both Scopus and WOS. In light of such findings, Iranian research policymakers are encouraged to consider revising tenure and promotion criteria for faculty members and researchers. Shifting the focus towards publication quality, rather than solely quantity, is likely to incentivize scholars to pursue impactful research and publications in higher-ranked journals.

Therefore, the primary motivation for our study was the growing evidence suggesting that NNS face more difficulties compared to native speakers (NS) in producing effective expository texts in English (Salazar, 2014) due to various factors, the most important of which might be their comparatively limited exposure to the target language (Appel & Murray, 2020). Out of a number of potentially important factors, we chose to focus on LBs as the ability to use them effectively is considered a hallmark of successful academic writing. These pre-fabricated phrases not only elevate writing (Hyland & Jiang, 2018) but also signal expertise in a specific field (Wei & Lei, 2011). NNS writers might all be familiar with recurrent sequences in

English, but they may struggle to produce them in sentences, which is an important ability for academic prose structure (Shin, 2019). That is why they have to seek the advice of editors to enhance the language and clarity of their writing and make it fluent and understandable to the widest audience (Carlsson et al., 2024). Therefore, if English language teachers intend to raise NNS authors' awareness of such discrepancies, they might need to become acquainted with EFL learners' unconventional use of LBs as well as the changes editors make to LBs during the editing process. However, there is a surprising paucity of research focusing on NNS authors' as well as copy editors' manipulations of LBs, as building blocks of academic writing.

## 2. LITERATURE REVIEW

### 2.1. Lexical bundles

Corpus linguistics has significantly impacted English for Specific Purposes (ESP) vocabulary studies. Researchers now use various corpora to analyze and describe discipline-specific English vocabulary, comparing word frequency and distribution across disciplines. Additionally, they explore the pedagogical implications of this corpus-based approach for effective teaching of ESP vocabulary (Hyland, 2022; Tomić, 2021). Phraseology, as a known subfield of vocabulary studies, is concerned with formulaic multi-word sequences, particularly idioms, collocations, and lexical bundles (Biber, 2009; Gezegin-Bal, 2019). It is important, however, to distinguish among LBs (e.g., *in terms of*), idioms, and collocations. Idioms (e.g., *beat around the bush*) are sequences of two or more words that possess a "non-compositional meaning" (Vilkaitė, 2016, p. 33), and collocations (e.g., *have a conversation, have fun*) are the frequent usage of certain words together or a specific word combination used in this manner. In contrast to idioms and collocations, LBs are not typically complete structural units (Gezegin-Bal, 2019). They are considered extended collocations that frequently serve "functional purposes" (Biber et al., 2004).

Lexical bundles were first introduced by Biber et al. in 1999 in their corpus-based study of English grammar. The importance of LBs as one of the key elements of competent and fluent linguistic production (Hyland, 2012; Salazar, 2014), has been extensively acknowledged and highlighted in language learning (Ardi et al., 2023). Given the increasing significance attributed to the role of LBs in language use and language learning, it became imperative to explore their nature. Further improvements on the LB approach were offered by authors such as Hyland (2008a), drawing inspiration from Halliday's (1994) systemic-functional linguistics to offer a threefold functional classification of LBs tailored specifically for written research genres. His classification was derived from three primary sources: research articles, PhD dissertations, and MA/MSc theses (Hyland, 2008a).

The bulk of research in this area falls into two main categories: inter-disciplinary and intra-disciplinary studies. Inter-disciplinary studies aim to find similarities and differences in the use of LBs across various disciplines (e.g., Cortes, 2004; Gezegin-Bal, 2019; Hyland, 2008b; Liu et al., 2023; Ren, 2021; Reppen & Olson, 2020). For instance, in his often-cited study, Hyland (2008b) analyzed 4-word bundles in RAs, doctoral dissertations and master's theses in the disciplines of microbiology, applied linguistics, electrical engineering, and business studies, and he found that LBs serve as a valuable tool for distinguishing written texts based on their respective disciplines.

Intra-disciplinary research, on the other hand, focuses on LBs within a single academic subject and provides corpora accounts (e.g., Jalali et al., 2015; Mbodj-Diop, 2016; Panthong & Poonpon, 2020; Shirazizadeh & Amirfazlian, 2020). For example, inspired by Hyland (2008b), Shirazizadeh and Amirfazlian (2020) compared the LBs in RAs, textbooks and dissertations in applied linguistics. Although bundles varied across texts in the same discipline, academic texts had many similarities. Thus, they hypothesized that regarding cross-generic bundles, some are discipline-specific and the others are cross-disciplinary.

The role of authors' L1 in the use of LBs has also been a topic of interest in intra-disciplinary research (e.g., Ädel & Erman, 2012; Kim & Lee, 2021; Yoo & Shin, 2022). As an example, in their study, Kim and Lee (2021) realized that English L2 writers frequently utilized verb phrase-based and text-oriented (TO) bundles, whereas English L1 writers tended to rely heavily on research-oriented (RO) bundles. Therefore, they suggested that English L2 writers would benefit from increased awareness of discipline-specific bundles in medical journal abstracts.

Another important point that was found in earlier studies concerned the overuse or underuse of certain LBs with particular functional or structural features (e.g., Anwar et al., 2020; Pan et al., 2016). In their study of RAs in psychology, Esfandiari and Barbary (2017) found that while English authors used more 4-word bundles, Persian authors used more 6-word clusters.

There is yet a newly developed third area adopting inter + intra disciplinary approach. Liu and Lu (2019) studied RA abstracts written in English by L1 Chinese and L1 English authors in chemistry and linguistics. They found inter-disciplinary differences between the two groups of authors, with the Chinese using LBs functionally and structurally similar to NS in linguistics rather than chemistry. Cao (2021) also compared the use of LBs across different research paradigms in education and psychology, finding significant differences some of which were associated with the particular paradigm.

## 2.2. RA editing

Academic writings which do not fully possess an acceptable level of linguistic quality may not stand a high chance of being published (Ehara & Takahashi, 2007). Thus,

before submitting to a prestigious journal, EAL authors often seek help from language experts, who are referred to by different titles e.g., authors' editors, text mediators, and so on, to do the final touch-ups on the articles (e.g., Flowerdew & Wang, 2016; Luo & Hyland, 2017). Therefore, the importance of editing has gained the attention of ERPP scholars and has been explored from different perspectives such as editor types (e.g., Luo & Hyland, 2017), editing techniques (e.g., Flowerdew & Wang, 2016), and the effects of editing on manuscript quality (e.g., Khalili & Sattarpour, 2020).

However, alongside all the significance globally attached to producing high quality RAs, and the fact that LBs pose challenges to NNS users of a language (Salazar, 2014) and the fundamental role that editors can play to linguistically enhance the quality of RAs, there is a surprising dearth of research exploring the effects of editing on specific aspects of NNS authors' productions. Therefore, the researchers intended to address this gap in the current study by focusing on the following research questions:

1. What are the most frequently used 4-word lexical bundles in the corpus of medical research articles written by Iranian non-native authors before and after editing?
2. What are the structural features of 4-word lexical bundles in the corpus of medical research articles written by Iranian non-native authors before and after editing?
3. What are the functional features of 4-word lexical bundles in the corpus of medical research articles written by Iranian non-native authors before and after editing?

### **3. METHOD**

#### **3.1. Compilation of the corpora**

To collect the data, we contacted 22 English-medium medical sciences journals approved by the Iranian Committee of Medical Science Journals of the Ministry of Health and Medical Education and ranked from A to A+. The editors-in-chief of eight journals agreed to share the electronic files of both the unedited versions and the edited or final versions of 15-20 articles, on the condition of anonymity. These editors had at least five years of experience and included five language experts (holding MA or PhD degrees in English language teaching) and three subject experts (who studied in English-speaking countries or were proficient language users). They began their task after the manuscripts had received initial acceptance in terms of content, and their task was to prepare accepted papers for publication by proofreading and addressing lexico-grammatical errors. We had no control over their specific techniques or the extent of modifications.

## 3.2. Target corpora

A total of 131 RAs published between 2018 and 2020 covering 19 medical subject areas were acquired. Despite our explicit request for original articles with the standard sections (Introduction, Method, Result, and Discussion), we had to exclude four case reports and three review articles that did not adhere to this structure. Therefore, our final data consisted of two subcorpora of 124 unedited RAs together with 124 edited versions. We removed the non-textual annotations like titles, diagrams, bibliographies, acknowledgement, tables, figures, footnotes, references, and appendices so that it would be easily readable by WordSmith Tools version 8 (Scott, 2020). Table 1 depicts the corpora in detail.

Corpus	Word count Running words (Tokens)	Word type	Mean length of texts (Tokens)	Standardized type/token ratio	Number of texts
Unedited RAs	460,983	24,979	3,717	50,957.90	124
Edited RAs	453,683	24,432	3,658	50,289.35	124

**Table 1.** Characteristics of the corpora

## 3.3. The procedure

### 3.3.1. Identifying LBs

There are essentially three criteria for identifying LBs, including bundle length, frequency, and distribution. We set the bundle length at 4 words as it is the most well researched, occurring 10 times more often than 5-word bundles, which are phrasal (Biber et al., 1999) and indicate a broader variety of structural and functional responsibilities (Hyland, 2012).

As for the second criterion, different frequency thresholds have been used in the literature, ranging from 10 (Biber et al., 1999), 20 (Cortes, 2004; Hyland, 2008a, 2008b; Shirazizadeh & Amirfazlian, 2021), 25 (Ädel & Erman, 2012; Zhang et al., 2021), to even 40 (Biber et al., 2004). As with the frequency cut-off, there is also considerable variability in determining LB distribution criteria. For instance, the minimum number of texts was set to be three by Chen and Baker (2010), five by Biber et al. (1999), and 10% of all texts by Hyland (2008a, 2008b). We adopted a rather conservative approach in setting the frequency of LBs at least 30 times per million words and their occurrence in at least 12 texts, which equaled 10% of all included texts.

As with most research in this area (e.g., Ädel & Erman, 2012), the primary list of LBs identified through the WordSmith software needed to be manipulated manually to yield a more representative list of bundles. First, we excluded word strings that do not seem to constitute an independent LB with recognizable structural and functional categories like *materials and methods* *the or et al reported*

that as well as context-dependent LBs like *World Health Organization (WHO)* or *University of medical sciences*. Second, overlapping word sequences that were actually parts of a longer word sequence could unjustifiably overrepresent the results. For example, since the concordance analysis revealed that all instances of the expression *on the results of* were preceded by the word *based*, we merged them into one unit *based on the results (of)*. It should be noted that we asked one other expert in the field to review the data and the manipulations in order to improve the data's internal validity (Creswell, 2014), and after an extensive negotiation session, we ultimately achieved complete consensus on the final LB list.

The results of concordance also proved useful in the allocation of certain LBs into structural or functional categories. The expression *considered as statistically significant*, for instance, was assigned to the category of *Passive verb + prepositional phrase fragment* in view of the accompanying "be" verb. There were also certain LBs that obviously formed one structural type despite being represented as two separate LBs. A case in point is *there was no significant* and *there were no significant*, which were merged into a single structural LB type, but their frequencies were combined. Given the pedagogical objectives of our research – to identify LBs used by NNS and points of similarity with and difference from proficient writers – we prioritized LBs that could stand on their own or contained useful collocations for prospective authors in ERPP classes. For instance, rather than including *an informed consent was* in our list, we picked *informed consent was obtained* so as to highlight the verb *obtain* that commonly collocates with *informed consent*.

### 3.3.2. Structural and functional coding of LBs

The remaining LBs were structurally coded based on their grammatical components and allocated into Biber et al.'s (1999) structural categories. In their structural taxonomy, LBs are analyzed under three main categories: noun, prepositional, and verb phrase-based bundles (see Table 2).

For the functional analysis, we adopted Hyland's (2008a, 2008b) categorization. For the functional analysis, Hyland's (2008a, 2008b) categorization was adopted. The decision to use this categorization rather than the earlier ones (e.g., Biber et al., 2004) is justified based on the fact that unlike Biber et al.'s (2004) earlier taxonomy, which stemmed from classroom discourse and textbooks, Hyland's framework is based on a thorough analysis of corpora, including RAs and theses. This alignment with our specific corpora enhances the relevance and accuracy of our finding. This framework consists of three major functions: a) research-oriented (RO) function through which "writers structure their activities and experiences of the real world", b) text-oriented (TO) function which is "concerned with the organization of the text and the meaning of its elements as a message or argument", and c) participant-oriented (PO) function which "is focused on the writer or reader of the text", and each function comprises its respective subcategories (Hyland, 2008a, pp. 49-50), which are presented in Table 3.

After identifying the LBs based on the three criteria elucidated above, employing WordSmith Tools version 8 (Scott, 2020), the LBs were structurally and functionally categorized. The type and token frequencies of these LBs, as well as their respective percentages, were computed. Subsequently, the log-likelihood (LL) tests, which are “useful for comparing the relative frequency of words or phrases” across corpora (Simpson-Vlach & Ellis, 2010, p. 492), were employed to ascertain the statistical significance of the modifications made to the corpus during the editing process. The LL tests were conducted using Rayson’s online calculator (<http://ucrel.lancs.ac.uk/llwizard.html>) at three levels of significance: .05, .01, and .001. The magnitude of LL value indicates the strength of the association, with positive values indicating overrepresentation and negative values indicating underrepresentation of an LB in corpus 1 (unedited RAs) relative to corpus 2 (edited RAs).

### 3.3.3. Ethical considerations

Firstly, the anonymity of the authors was strictly maintained throughout the study since the editors-in-chief provided us with the manuscripts in which all identifying information was removed, ensuring that the identities of the individuals remained highly confidential. Secondly, upon receiving the files containing suggested changes for the authors, the names of the reviewers had been intentionally omitted and replaced with reviewer 1, as an example. Moreover, this study adhered to the ethical guidelines set forth by the Institutional Review Board (IRB) [IR.TBZMED.VCR.REC.1401.280].

## 4. RESULTS AND DISCUSSION

Our corpus included 460,983 running words in the unedited and 453,683 in the edited versions of RAs. Regarding the first research question, our initial quantitative analysis revealed that there were 61 types of 4-word LBs, including 1,487 tokens in the unedited corpus against 65 types and 1,751 tokens in the edited articles (see the Appendix), comprising 1.3% and 1.5% of the total number of words, respectively. In other words, though the editing process has cut the total number of words by 1.6%, it has added up 6.6% to the types and 17.3% to the tokens of LBs. In addition, the achieved value for LL statistics was found to be 24.9 with a  $p$ -value  $< .001$ , indicating a statistically significant difference between the two corpora.

Besides the increase in the type and token frequency brought about by the editing, there is also a 0.2% rise in the overall number of LBs in proportion to the total number of words in the edited articles. Therefore, the total ratio of LBs has increased after editing in view of the fact that LBs have normally been reported to make up 1.5%-1.9% LBs in academic texts. The type/token ratio might well appear slightly larger for the unedited versions (1/24 vs. 1/26), suggesting that the unedited LBs were less repetitive. However, the unedited corpus comprised the products of 124



authors while the edited versions were edited by only eight editors, so some redundancy or repeated LBs are natural and might be attributed to the editors' idiosyncrasies.

We found 54 LB types shared across the two subcorpora, 28 of which appeared at intact or nearly the same frequencies ( $\pm 3$ ) across the two subcorpora, and 11 LBs had been added by the editors and were thus exclusive to the edited versions while seven LB types had been deleted in the editing process. The five most frequent LBs in the unedited data were *on the other hand*, *one of the most*, *results of this study*, *as well as the*, *there was no significant*, which had been used 84 to 128 times per million words, constituting 16.4% of LBs. However, the top five LBs in the edited articles were *this study aimed to*, *there was/were (be) no significant*, *is one of the*, *one of the most*, *there was a significant*, and their frequency of occurrence ranged from 119 to 160 per million words, making up 17.3% of the total number of LBs in the edited versions of our data. The five most common LBs rarely constitute more than 11% of all LBs in the literature (e.g., Shirazizadeh & Amirfazlian, 2021), suggesting that NNS authors and copy editors overused a fixed set of formulaic expressions.

Upon closer examination of the individual LB types to have undergone a sharp increase in the editing process (e.g., *this study aimed to*, *there was a significant*, increasing 217% and 69%, respectively), we found that this increase is not necessarily a qualitative improvement in the use of LBs as far as NS norms are concerned. Copy editors were found to be unscrupulously utilizing attended *this* or existential *there* for resultative rather than statistical purposes (Biber et al., 1999), which is untypical of academic prose (Ädel & Erman, 2012) and a common slip by less proficient NNS authors (Esfandiari & Barbary, 2017). There are rather contradictory reports on NS and NNS authors' use of LBs. Some have remarked that NNS authors use fewer LBs with less variation (Erman, 2009; Esfandiari & Barbary, 2017). Others have reported that less competent writers use LBs more than experts to demonstrate their academic writing expertise, avoiding less common word strings which might be inappropriate (e.g., Pan et al., 2016; Zhang et al., 2021). Our findings lean towards the former view in the unedited subcorpora, although the editing process seems to have changed the manuscripts in this respect, to a limited extent, by adding 0.2% more LBs to the total number of words.

#### 4.1. Structural analysis

Concerning the second research question, as mentioned above, we used Biber et al.'s (1999) structural categories to get a fuller picture of the LBs across the two subcorpora (see Table 2). LBs that did not lend themselves neatly to any of the proposed structural categories were so numerous that they had to be accounted for. We added a further subcategory of *Noun/noun phrase + verb (active/passive)* to accommodate the data.

Structures	Before editing			After editing			LL
	Type	Token	%	Type	Token	%	
Noun phrase with of-phrase fragment <i>results of this study</i>	12	313	21.04	10	257	14.67	+4.65*
Noun phrase with other post-modifier fragments <i>an increase in the</i>	7	153	10.28	5	129	7.36	+1.68
Pronoun/noun phrase + be (+ ...) <i>there was no significant</i>	3	97	6.52	3	135	7.7	- 6.87**
Prepositional phrase with embedded of-phrase fragment <i>at the end of</i>	6	145	9.75	5	133	7.59	+0.34
Other prepositional phrase (fragment) <i>on the other hand</i>	4	143	9.61	5	152	8.68	-0.44
Anticipatory it + verb phrase/adjective phrase <i>it should be noted</i>	2	40	2.68	2	34	1.94	+ 0.40
Passive verb + prepositional phrase fragment <i>are presented in table</i>	5	92	6.18	8	164	9.36	-21.69***
Copula be + noun/adjective phrase <i>may be due to</i>	4	95	6.38	6	166	9.48	-20.71***
(Verb phrase +) that-clause fragment <i>this study showed that</i>	4	94	6.32	4	104	5.93	- 0.68
(Verb/adjective +) to-clause fragment <i>to be able to</i>	0	0	0	2	28	1.59	- 39.26***
Adverbial clause fragment <i>as can be seen</i>	0	0	0	0	0	0	—
Other expressions <i>as well as the</i>	5	137	9.21	6	189	10.79	- 9.18**
Sub- CATEGORY: Noun (noun phrase) + verb (active/passive) <i>this study aimed to</i>	9	178	11.97	9	260	14.84	- 16.78***
Total	61	1,487	~100	65	1,751	~100	- 24.9***

LL= Log-likelihood; \*\*\* means  $p$ -value <0.001; \*\* means  $p$ -value <0.01; \* means  $p$ -value <0.05.

**Table 2.** Structures of LBs before and after editing

Even a cursory glance at Table 2 reveals that our data seem non-native in certain ways, even though the genre is highly structured, and the articles have all been expertly edited. One obvious source of divergence from the norms commonly reported in the literature is the fact that our data contained no LBs meeting the inclusion criteria in the 10th and 11th categories, i.e., *Verb/adjective + to-clause fragment* and *Adverbial clause fragment* in the unedited articles with only two types added upon editing in the 10th, while these categories often comprise close to 10% of LBs (Jalali et al., 2015; Zhang et al., 2021).

Another source of divergence has to do with the accumulation of a significant portion of LBs (21% in the unedited RAs and 25% in the edited ones) in the last category, *other expressions*, of which more than 12% and 15% fit in the *Noun (noun phrase) + verb (active/passive)* construction, which is of course not observed frequently enough in NS productions to be mentioned as a legitimate structural category by Biber et al. (1999). This category has seldom been reported to include a significant portion of LBs in the manuscripts produced by expert writers, often consisting of less than 5% of LBs (Zhang et al., 2021), with the highest we found being 10% (Shirazizadeh & Amirfazlian, 2021). The most likely reason behind this unconventional reliance on *Noun (noun phrase) + verb (active/passive)* construction by our authors probably has to do with the tendency of NNS writers to repetitively draw on already familiar, or basic sentence structures. Moreover, it was particularly unanticipated to find the editing process aggravating the situation by adding a further 4% (LL=16.78,  $p$ -value<.001) to an already inflated number because language experts working as copy editors are expected to, if anything, enhance the quality of papers, making them read well and meet the standards of the academic community. The investigation of the specific cases of the editors employing this category revealed that both the authors' and the editors' obsession with grammatical accuracy, and their predisposition to using repetitive structures (e.g., *present study aimed to*, *consent forms were obtained*) to express similar content underlie this unconventional amassing of LB tokens in this category (Example 1).

Unedited (1): *Therefore, present study was done to investigate DNA integrity and protamine transcripts content in ejaculated spermatozoa of Iranian men with unexplained infertility.*

Edited (1): *The present study aimed to investigate DNA integrity and protamine transcripts contents in ejaculated spermatozoa of Iranian men with unexplained infertility.*

There are also other dissimilarities to the data reported in the literature in terms of the proportion of LBs used in different structural categories. For instance, prepositional phrases have often been reported to constitute the largest category in terms of types and tokens of LBs, comprising around 45% (Jalali et al., 2015), 36% (Panthong & Pooapon, 2020), and 31.37% (Mbodj-Diop, 2016) of the total number of LBs in RAs in medicine or at least 30% in RAs in other fields (e.g., Kwary et al., 2017), but they barely reached 19% in the unedited subcorpus, which had been further reduced to 16.5% in the edited articles. However, this change was not significant in terms of log-likelihood value (LL=0.34,  $p$ -value>.001). Apprentice writers have been found to use prepositional phrases far less frequently than expert writers (Zhang et al., 2021), and if the NNS authors' productions resemble those of apprentice writers, the editors' interventions seem to have done little in this regard to change the picture.

The second most frequently employed category in both subcorpora was *Noun phrase with of-phrase fragment* category, consisting of 12 types and 313 tokens in

the unedited subcorpus which comprised 21.04% of the total number of LBs. When it is combined with the other NP category i.e., *Noun phrase with other post-modifier fragments*, which included seven types and 153 tokens, they together made up 31.33% of the total number of bundles in unedited articles. This structure has often been reported to be the most common of all structures in academic texts (e.g., Chen & Baker, 2010; Cortes, 2004; Hyland, 2008a) and Biber et al. (1999) note that it can constitute up to 60% of structural categories. What was noteworthy in our data, however, was the statistically significant reduction of this structure in the editing process (LL=4.65,  $p$ -value<.05). Analysis of concordance lines seemed to point to the editors' tendency to overuse formulaic constructions e.g., replacing *Noun phrases* with *S+V* (Example 2), which might not be commonly encountered in NS productions as explained above.

Unedited (2): *According to the results of the study, polypharmacy can decrease medication adherence ...*

Edited (2): *Our findings revealed that polypharmacy can decrease medication adherence ...*

Another structural category to have been rather overused by our authors, not undergoing much change for the better in the editing process (LL=0.68,  $p$ -value>.001), was *(verb phrase) + that clause fragments* which consisted of over 6% of the bundles in both subcorpora (Examples 5 and 6) while it has often been reported to constitute less than 6% in various academic fields (e.g., Chen & Baker, 2010; Esfandiari & Barbary, 2017; Yin & Li, 2021) or even less in medical RAs, less than 2% (Jalali et al., 2015; Mbodj-Diop, 2016). However, even though this structural category is used at an unusually much higher rate by the authors, as shown in Example 3, the editors seemed to be content with this and do not modify this structure. The most likely reason behind this is L1 transfer because student writers of Persian background are known to overuse this structure in their writings; however, it was not quite expected to see this structure find its way to the scientific prose produced by Iranian academics.

Unedited & Edited (3): *The results of this study showed that the biosynthesized nanoparticles exhibited antibacterial activity against...*

The editing process appears to have had minimal impact on improving or modifying papers concerning the structural categories of LBs, whether they were overused or underused in the unedited versions. While editors do not intentionally alter 4-word bundles in academic texts, LBs are crucial for effective scholarly communication. The rigidity of the scientific paper format and editors' primary focus on rectifying lexico-grammatical errors may explain this phenomenon

## 4.2. Functional analysis

Regarding the third research question, our analysis encountered challenges related to allocating certain linguistic features to functional categories within Hyland's categorization. Despite the inherent subjectivity in text analysis, we diligently addressed inconsistencies and achieved 100% agreement through extensive discussion and concordancing (see Table 3). However, in functional analysis, our data displayed characteristics not resembling those commonly observed in NS manuscripts, with the editing process playing a peculiar role, sometimes pushing the data towards and at times away from what is typically found in NS academic productions.

Functions		Before editing			After editing			LL
		Type	Token	%	Type	Token	%	
Research-oriented	Location <i>at the end of</i>	2	40	2.68	1	18	1.02	+ 8.21**
	Procedure <i>test was used to</i>	15	303	20.37	20	460	26.27	- 35.09***
	Quantification <i>a wide range of</i>	5	112	7.53	3	101	5.76	+ 0.41
	Description <i>this cross sectional study</i>	16	361	24.27	15	433	24.72	- 7.74**
	Topic <i>by the ethics committee</i>	1	22	1.47	1	26	1.48	- 0.40
<b>Total</b>		<b>39</b>	<b>838</b>	<b>56.32</b>	<b>40</b>	<b>1,038</b>	<b>59.25</b>	<b>- 24.67***</b>
Text-oriented	Transition Signals <i>as well as the</i>	2	98	6.59	2	84	4.79	+ 0.87
	Resultative Signals <i>as a result of</i>	11	302	20.3	12	330	18.84	- 1.73
	Structuring Signals <i>are presented in table</i>	1	20	1.34	1	24	1.37	- 0.43
	Framing Signals <i>(be) based on the results</i>	3	81	5.44	4	119	6.79	- 7.88**
<b>Total</b>		<b>17</b>	<b>501</b>	<b>33.67</b>	<b>19</b>	<b>557</b>	<b>31.79</b>	<b>- 3.93*</b>
Participant-oriented	Stance features <i>may be due to</i>	4	127	8.54	5	138	7.88	- 0.65
	Engagement features <i>it should be noted</i>	1	21	1.41	1	18	1.02	+ 0.19
<b>Total</b>		<b>5</b>	<b>148</b>	<b>9.95</b>	<b>6</b>	<b>156</b>	<b>8.9</b>	<b>- 0.36</b>

LL= Log-likelihood; \*\*\* means  $p$ -value <0.001; \*\* means  $p$ -value <0.01; \* means  $p$ -value <0.05.

**Table 3.** Functions of LBs before and after editing

#### 4.2.1. Research-oriented lexical bundles

Research-oriented bundles dominated our data, comprising 56% of all LBs (with 39 types and 838 tokens) in the unedited manuscripts and 59% (with 40 types and 1,038 tokens) in the edited ones. Although editing resulted in a statistically meaningful rise (LL=24.67,  $p$ -value<.001) in the occurrence of the RO category, attributing this solely to enhanced linguistic quality or native-like production is premature and further analysis of individual subcategories is necessary. Inside this category, *Description* and *Procedure* bundles accounted for 79% (43% and 36%) and 85% (41% and 44%) of all RO bundles in the unedited and edited subcorpora, respectively. The abundance of RO bundles in data on the scientific discourse of hard sciences cannot be odd per se since these bundles relay empirical evidence and detailed information about the research (Allen, 2010), and as Hyland (2008b, p.15) remarks, they emphasize “the empirical over the interpretive, minimizing the presence of the researchers and contributing to the “strong” claims of sciences.” These bundles are often reported to be the largest proportion of LBs in different works (e.g., Chen & Baker, 2010; Shirazizadeh & Amirfazlian, 2021; Zhang et al., 2021), however, they rarely exceed 55% in RAs. The fact that they exceeded 60% in the edited articles here indicates a significant difference in NNS productions. As a result of the apprentice writers’ tendency to maximize impersonality and avoid “linguistic realizations of voice in their academic writings” (Botelho de Magalhães et al., 2019), only student writers of dissertations rely on RO bundles as heavily.

It is also noteworthy that apprentice writers, have been reported to make extensive use of *Description* bundles as a way of “demonstrating their mastery over the scope, content, and methodological aspects of their research” (Shirazizadeh & Amirfazlian, 2021). Interestingly, although the majority of our authors are recognized figures in their fields, they seem to have resorted to the same linguistic strategies as student writers in their productions, which might be blamed on the fact that their linguistic competence is still far from full-fledged. Nonetheless, while the results showed that editing meaningfully increased *Description* (LL=7.74,  $p$ -value<.01) and *Procedure* (LL=35.09,  $p$ -value<.001) subfunctions compared to the overall size of the corpora, a closer look could reveal important details on the *Description* subcategory. First of all, the statistically significant rise has only been marginal according to the LL value, and more importantly, if the frequency of this subcategory is compared with the total tokens of only RO category, we find that the overuse of *Description* has actually been slightly toned down by the copy editors, who have cut it by 2% (from 43% to 41%) among RO subfunctions (Example 4).

Unedited (4): *Exclusion criteria: Mean baseline B-line numbers  $\geq$  3, family history of allergy to local anesthetics, pulmonary, cardiovascular or hematological disease.*

Edited (4): *Patients with mean baseline B-line numbers  $\geq$  3, a family history of allergy to local anesthetics, and pulmonary, cardiovascular, or hematological diseases were excluded from the study.*

Given the fact that our primary objective was to characterize NNS manuscripts in terms of their use of LBs and the modifications brought about in the editing process in this regard, we might as well move beyond overall percentages and proportions at this point to continue with more specific and tangible analyses within the individual categories. In the meantime, it seems reasonable to draw comparisons between the final versions of the manuscripts after the editing process and the NS manuscripts to establish whether and to what extent the editorial modifications have pushed the manuscripts towards NS production norms. Rather unexpectedly, such categorical comparisons eventually yielded the most conspicuous dissimilarities between the NNS and NS manuscripts. For example, *Noun phrase + of* structural pattern, which is considered a common characteristic of the academic prose, and particularly the scientific written register (Allen, 2010) and is known to abound in the *Description* subfunction (Hyland, 2008a; Pan et al., 2016), comprised only two out of 16 (12.5%) of LB types in our corpus. Furthermore, this pattern has been reported to be employed rather differently by apprentice and expert writers, with apprentice writers making a considerable effort describing their experiment or providing detailed information while expert writers use this pattern to convey more generalized or abstract information (Allen, 2010; Zhang et al., 2021). Underused in our corpus, *NP + of* construction is employed in two LBs in the *Description* subfunction – *examination of the subjects, analysis of the data* – which appears to more closely resemble the products of apprentice writers. Obviously, far from conveying abstract or generalized information, these LBs overtly refer to the stages of data analysis or research procedures, and the editors' interventions seem to be conspicuously absent to bring about any changes for the better in this respect.

Another source of deviation was the emergence of LBs which hardly belonged to any of our functional categories; we put them in categories with the highest affinity for their functional characteristics. For instance, mere noun phrases *this cross-sectional study, significant difference in the, no significant difference in, or study was approved by* were among the LBs that we seldom found in any of the data reported in the literature and were peculiar to our NNS corpus (Examples 5 and 6). Such LBs are used frequently enough to meet inclusion criteria, which might indicate that authors in our country overuse formulaic expressions that might help them write in rigid grammatical patterns of dubious appropriateness. The editors seem so accustomed to such word strings that, like the authors, they appear to give little consideration to the novelty of the sentences and do not reformulate them during editing. As it is shown in examples below, such uncommon LBs appearing in the original drafts were not touched on in the edited versions, either.

Unedited & Edited (5): *In this cross-sectional study, Papanicolaou staining was used to count the micronucleus in ...*

Unedited & Edited (6): *The present study was approved by the Animal Ethics Committee of ...*

#### 4.2.2. Text-oriented lexical bundles

Text-oriented lexical bundles establish cohesive ties, frame arguments, and signpost texts providing for reader friendliness of the texts. As illustrated in Table 3, the number of tokens and LL test results both revealed an increase in the TO frequency after editing; however, the rather low LL value (LL=3.93) and a matching significance level of .05 seem to indicate that the editorial work may not have been so approvable after all as the TO token ratio had even declined by 1.88% (from 33.6% to 31%). The excessive use of RO bundles by NNS academics, coupled with a pronounced underuse of TO bundles, has been reported to be a characteristic of apprentice writers (Hyland 2008a, 2008b; Shirazizadeh & Amirfazlian, 2021). Since three out of eight editors in our study were subject experts (not language experts), their primary concerns seem to match those of apprentice writers in this respect.

The underuse of TO bundles seems to get more pronounced when individual categories are considered. Resultative signals were by far the most frequently used of TO bundles, comprising 60% of TO bundles in the unedited corpus, which stayed almost the same (59%) in the edited corpus, and no significant difference between the corpora (LL=1.73,  $p$ -value>.001) was found regarding this category. Reporting results could be the main goal of hard sciences, and thus LBs performing this function could be in the spotlight. The NNS authors seem to have overused this resource, leaving little room for TO LBs that could improve organization, cohesion, and coherence. Overuse of resultative signals by NNS authors has been reported in soft sciences like psychology, where authors seemed to have been unaware of reporting or interpreting research processes (Esfandiari & Barbary, 2017).

Framing signals, comprising 16% and 21% of TO LBs in the unedited and edited subcorpora, were the second least frequently used subcategory, employed with little variety. Given that the primary function of these bundles is to limit the generality of statements through exemplification, specification, and comparison, three structurally repetitive LBs might not be the best resource to carry out such functions. The bundles in this subcategory were *based on the results, compared to the control, consistent with the results*, while other LBs more typical of such functions in the literature, e.g., *in terms of the, with respect to the* were notoriously absent from our data.

One of the two transition signal types in our subcorpora was *on the other hand*, which is typical of academic discourse and used by NS academics (Allen, 2010; Esfandiari & Barbary, 2017; Hyland 2008a, 2008b). Similarly, this LB was the most frequent in our unedited subcorpus while editing reduced its frequency by over 20%, removing it from the top five most frequent bundles (Example 7). The analysis of concordance lines revealed that on several occasions *on the other hand* had been used inappropriately and was replaced by other grammatical means.

Unedited (7): *On the other hand, there is a need for maternal study in newborns with COVID-19, not only due to ...*



Edited (7): *Moreover, there is a need for maternal study in newborns with COVID-19 not only due to ...*

The most likely reason for overusing the LB *on the other hand* might concern the authors' extensive reading in their fields of study, where they frequently encountered this phrase, but their limited linguistic competence led them to use it inappropriately – hence its deletion in the editing process. However, the fact that our subcorpora only contained two transition signal types, namely *as well as* and *on the other hand*, seems to support the claim that NNS authors, and copy editors in general, are overly concerned with factual reports and the mechanical framework of their research, while paying comparatively little attention to the additive, or contrastive links, which provide for manuscript coherence and reader friendliness. The situation is hardly different with structuring signals, which made up less than 5% of TO bundles. There was only one LB type, *are presented in table*, in both subcorpora, the frequency of which had slightly increased in the editing process. This is well below the average use of this category of LB by NS authors in a variety of fields (Yin & Li, 2021), and demonstrates the fact that NNS authors are so obsessed with the content and technical aspects of writing a scientific paper that they seem to become almost inattentive to managing their arguments or using guiding expressions for their readers so that they would know what to expect in subsequent sections. Again, this seems to apply to the editors as well, who appear to be overly concerned with technical and linguistic accuracy and ignorant of such considerations.

#### 4.2.3. Participant-oriented lexical bundles

As the name suggests, these LBs emphasize the personal aspects of academic texts. They had the lowest frequency in our data, comprising 10% of all LBs in the unedited corpus and 9% after editing. Among the three functional categories of LBs, it was the only category in which no statistically significant difference was found between unedited and edited corpora (LL=0.36,  $p$ -value>.001). These bundles account for 10% of the total LBs (e.g., Hyland 2008b; Shirazizadeh & Amirfazlian, 2021), however in some studies, they account for 24% by NS and 17% by NNS in soft sciences (Esfandiari & Barbary, 2017). NS often use PO bundles more frequently than NNS (e.g., Anwar et al., 2020) since appropriate use of these resources has been challenging for NNS authors whose view of the type of relationship they can establish with their readers is often “constrained by considerations of institutional power, rhetorical confidence, and, perhaps, cultural preference” (Hyland, 2005, p. 375).

Our data had only one engagement LB, whose frequency was reduced during editing, though not significantly (LL=0.19,  $p$ -value>.001) (Example 8). In the unedited corpus, there were four types of stance LBs, including *one of the most*, *may be due to*, *is the most common*, *play an important role*, with one further type, *might be due to*, added in editing, which was not a statistically significant change (LL=0.65,

$p$ -value > .001). Thus, if NNS authors neglect establishing a dialogic relationship with their readers, so do the copy editors who may even delete – rather than add – a PO bundle in their editorial interventions. Thus, as with Chinese writers of English who avoided interventionist stance features due to cultural standards (Hyland, 2012), Iranian editors seem not to pay much attention to the importance of using these rhetorical resources.

Unedited (8): *It should be noted that differences of the culture, level of education and economic status could affect the results.*

Edited (8): *Cultural differences, level of education, and economic status could affect the results.*

Finally, some editorial changes might well challenge authorial authority. For example, the analysis of concordance lines revealed that the copy editors had replaced *may be due to* with *might be due to* on four occasions as well as replacing other bundles like *this is due to* with *might be due to* in order to indicate a higher degree of probability (Example 9).

Unedited (9): *This is due to small sample of the compared study or due difference of life style ....*

Edited (9): *This might be due to the small sample size of the compared study, or because of lifestyle ....*

This is a common phrase in academic discourse; however, it is unclear whether the author intended the degree of probability it conveys. Considering the function of stance LBs, one might wonder whether a copy editor has the authority to manipulate the writer's assessment of or commitment to textual concepts.

## 5. CONCLUSION

We initiated this study to investigate the use of LBs in medical RAs written by Iranian NNS authors, and to establish the extent to which editing modified the frequency of LBs in terms of structure and function. Quantitatively, the editing was found to increase the type and token frequency of LBs by 6.6% and 17.3%, respectively, which can be considered an improvement in getting closer to the productions of NS writers who are known to use a higher proportion of LBs in their manuscripts (e.g., Ädel & Erman, 2012; Chen & Baker, 2010).

Structurally, our corpora were quite different from those of other studies in that a significant number of LBs had to be placed in the category of *other expressions*. Yet, as in most other works, *phrasal* bundles constituted a significant portion of our bundles, but this proportion, contrary to our expectation, actually declined in the

editing process. As for the functional categories, RO had the highest frequency, followed by TO, and PO categories. Our corpus of unedited RAs was quite similar to that of other studies regarding the use of RO bundles, and the editing did appear to bring about some improvements through introducing some modifications, albeit minor ones, in the *Description* and *Procedure* subcategories. However, our authors had not employed TO bundles to the extent that is normally reported and the editors had not done much to change the picture. And finally, PO bundles made up close to 10% of our bundles, which is almost the same as that in most other studies (e.g., Anwar et al., 2020; Hyland, 2008b). All in all, the copy editors' work, when benchmarked against data on NS productions, does not seem to have been quite as effective as normally expected in terms of the structural and functional improvement of the LBs in RAs.

Our findings might have pedagogical implications for ERPP teachers, prospective authors, and copy editors. These results can inform instructional programs, highlighting problem areas related to LB usage by NNS authors, particularly Iranians. For instance, cases of excessive LBs in categories not aligned with established classifications or significant underuse of PO bundles by NNS authors could be evidence-based cases that require attention on the part of material developers and instructors. Copy editors can also benefit by recognizing the need to address rhetorical aspects beyond lexico-grammatical correctness, including LB usage, to enhance paper quality.

Moreover, future research could prove very useful if the works of NNS copy editors are compared with those of NS. We also suggest that shorter and longer word sequences be included in future research so as to get a more complete picture of how LBs are employed by NNS authors and modified by editors.

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### Appendix

Lexical bundles before and after editing (the LBs exclusive to each version are highlighted)

	<b>BEFORE editing</b>	<b>frequency</b>	<b>AFTER editing</b>	<b>frequency</b>
1	on the other hand	59	this study aimed to	73
2	one of the most	59	there was/were (be) no significant	61
3	results of this study	48	is one of the	59
4	as well as the	39	one of the most	56
5	there was no significant	39	there was a significant	54
6	according to the results	36	results of this study	52
7	compared to the control	36	with the results of	47
8	studies have shown that	34	on the other hand	46
9	results of the present	33	compared to the control	43
10	there was a significant	32	as well as the	38
11	for the treatment of	32	significant difference between the	36
12	is one of the	32	study was approved by	34
13	with the results of	31	informed consent was obtained	33
14	may be due to	30	studies have shown that	32
15	test was used to	28	no significant difference was	32
16	based on the results	27	results showed that the	31
17	between the two groups	26	between the two groups	31
18	significant difference between the	26	was obtained from all	31

19	this study was to	26	results of the present	30
20	mean age of the	25	according to the results	30
21	an increase in the	25	participate in the study	29
22	this cross sectional study	25	for the treatment of	29
23	results showed that the	25	test was used to	28
24	play an important role	24	this cross sectional study	28
25	this study was conducted	24	may be due to	26
26	informed consent was obtained	24	by the ethics committee	26
27	this study aimed to	23	based on the results (of)	26
28	analysis of the data	22	is consistent with the	25
29	as one of the	22	consistent with the results	25
30	by the ethics committee	22	as one of the	24
31	significant difference in the	21	a significant difference between	24
32	at the time of	21	are presented in table	24
33	it should be noted	21	present study aimed to	24
34	are presented in table	20	was not statistically significant	22
35	aim of this study	20	play an important role	22
36	no significant difference in	20	study was carried out	22
37	as a result of	20	no significant difference in	21
38	this study showed that	20	this study showed that	21
39	participate in the study	20	analysis of the data	20
40	results of the study	19	no significant difference between	20
41	analysis and interpretation of	19	this study was to	20
42	a significant difference between	19	might be due to	20
43	at the end of	19	our results showed that	20
44	it has been reported	19	analysis and interpretation of	19
45	was not statistically significant	19	according to our results	19
46	a wide range of	18	(was)considered as statistically significant	18
47	consistent with the results	18	a wide range of	18
48	study was carried out	18	at the end of	18
49	study was approved by	18	it should be noted	18
50	findings of this study	17	was obtained from the	17
51	a systematic review of	17	findings of this study	17
52	no significant difference between	17	analysis was performed using	16
53	examination of the subjects	16	examination of the subjects	16
54	can be used as	16	it has been reported	16
55	was obtained from the	15	can be used as	16
56	that there is no	15	was carried out in	16
57	analysis was performed using	15	were excluded from the	16
58	was obtained from all	14	this study was conducted	16
59	is the most common	14	a systematic review of	15
60	sample size was calculated	14	as a result of	15
61	data were analyzed using	14	aim of this study	14
62			is the most common	14
63			Used to evaluate the	14
64			Used to determine the	14
65			sample size was calculated	14