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Text-internal variation in the use of linking adverbials in the English-medium research article

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Abstract

Linking adverbials (LAs) facilitate the logical flow of ideas, particularly in academic writing, where they are more common than in other registers. This study employs Liu's (2008) taxonomy of LAs to explore text-internal variation in their frequency and distribution by semantic category across the rhetorical sections of the English-medium research article (RA). Using a section-coded corpus of 200 empirical RAs published in high-impact journals in public health, data are presented to reveal that: (i) textual cohesion in the sections is largely constructed through a small set of LAs; (ii) yet, the sections differ significantly in LAs' frequency and preferred semantic categories, with Methods differing the most from the other sections; (iii) the contribution of LAs to the construction of textual cohesion is greatest in Discussions and least in Methods; (iv) the sections share many high-frequency LAs, which however fulfil the sections' distinct communicative purposes to varying degrees.

Keywords

linking adverbial, research articles, rhetorical sections, text-internal variation, section-specific

1. Introduction

Linking adverbials (LAs) are essential devices for textual cohesion, since they specify how sentences in discourse are related to one other, helping the reader "to interpret information that follows in light of what has alreadys been presented" (Appel, 2020, p. 1). Their competent use in academic writing is thus vital to the rhetorical efficiency of scientific claims (Gao, 2016). This corpus-based study provides a quantitative and qualitative insight into text-internal variation in LA use across the rhetorical sections of the English-medium research article. Regarding the quantitative analysis, the LAs found in the corpus are compared across the Introduction-Method-Result-Discussion (IMRD) sections to identify their section-specific frequency and distribution by semantic category. Concerning the qualitative analysis, specific examples of the most frequent LA items in the four main categories are discussed to show how they are connected to the rhetorical purposes of different sections.

Each rhetorical section in a research article (RA) fulfils different communicative functions and is thus marked by its specific rhetorical and linguistic choices. Introductions provide background information on the topic, objectives of the investigation and its rationale, developing these ideas through the general-to-specific flow of thought; Methods describe and justify the materials, procedures and tools used to conduct the study; Results present and comment on the findings; and Discussions interpret the results and explain their significance and implications while following the specific-to-general flow (Swales and Feak, 2012; Zhang, 2022). As a result, "Introductions and Discussions are socially oriented and interpretive in nature" whereas "Methods and Results are descriptive in nature and oriented toward research practices" (Zhang, 2022, p. 3). For these differing rhetorical goals to be achieved, the semantic relations between the ideas in each section have to be established through linking devices that correspond to the intended meanings. It is thus likely that the set of LAs will vary across the sections or that specific LA items will serve the sections' individual communicative purposes to varying degrees. These are the phenomena the present study seeks to explore and better understand.

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2. Linking adverbials

The term "linking adverbials" is just one of a few often interchangeable and overlapping labels that are commonly used for the devices signalling "semantic connections between spans of discourse of varying length", including "phrases, sentences, paragraphs or longer" (Biber, et al., 1999, pp. 558, 549). As Leech and Svartvik (2002, p. 142) claim, the fact that LAs provide adverbial links connecting "longer stretches of language, perhaps whole sentences" allows to distinguish them from coordination that is "a 'looser' connection (…), because it is more vague and less emphatic" as well as from subordination that "tends to give a clause a less important part in the information given by a sentence". Specifically, while LAs "set up contextualizing relationships between portions of text", indicating the meanings carried by them through reference to the preceding or following context (Hasselgård, 2010, p. 20), coordinators and subordinators provide semantic but also syntactic connections, though only at or below the clause level (Liu, 2008, p. 492). Coordinators establish linear relationships between linguistic constituents that are of equal semantic value, grammatical rank and syntactic status, forming a weak connection between them, as each can function on its own; in turn, subordinators establish dependency relationships by connecting clauses in a way that clearly shows which is dependent upon the other, that is, which is more semantically salient than the other. Despite such clear differences between the three main ways in which ideas can be put together in discourse, scholars often entangle themselves in the terminology maze surrounding linking devices. This confusion has been resolved by Liu (2008, pp. 492-493), who explains that the terms "connectives", "logical connectors" and "connective/logical adjuncts" cover both adverbials and conjunctions (i.e. coordinators and subordinators), whereas the terms "conjunctive/linking adverbials", "conjuncts" and "connective adverbs" refer specifically to adverbials. It is the latter group of connectors that is investigated in this study under the term "linking adverbials". One final comment is that LAs are also believed to function as discourse markers signalling "the relationship of the basic message to the foregoing discourse", which means that they contribute to the procedural meaning of a sentence by providing "instructions to the addressee on how the utterance to which the discourse marker is attached is to be interpreted" (Fraser, 1996, p. 169, 186).

Regarding the realization forms of LAs, following Sinclair (2005), the main division is into lexical (e.g. *though*) and phrasal (e.g. *in addition*), however, finite clauses (e.g. *that is to say*) and non-finite clauses (e.g. *added to that*) functioning as LAs are also possible. Semantic classifications of LAs are somewhat more problematic, since individual forms "can carry several meanings for different communicative purposes in different contexts", as exemplified by *then*, which depending on the context can express a summative, inferential or adversative semantic relationship (Yin, 2016, p. 1). Thus, it is difficult to reach unanimity in understanding the interplay between the item's semantic meaning, form and pragmatic function. As a result, the main taxonomic categories of LAs proposed by various scholars differ in the labels attached to them and in their very number. For instance, Carter and McCarthy (2006) divide LAs into nine types: additive, concessive, contrastive, inference, listing, meta-textual, resultative, summative, and time; Greenbaum (1969), into eight: listing, transitional, summative, explicatory, contrastive, illative, inferential, and temporal transitional; Sinclair (2005), into seven: addition, causes, conjunctions, contrasts and alternatives, ordering points, parallel, and sequence in time; Biber, et al. (1999), into six: enumeration, summation, apposition, result/inference, contrast/concession, and transition; whereas Liu (2008), only into four: additive, adversative, causal, and sequential.

According to Greenbaum (1969, pp. 37-44), the basic syntactic features of LAs include lack of pre- or postmodification; occurrence in various clause types, including *yes-no*, *wh-* and indirect questions[1] (e.g. *Why is she nevertheless happy?*), imperative and optative clauses e.g. *Let there thus be two options.*), verbless clauses (e.g. *If possible then, let me know.*), clauses with the copular *be* and other verbs (e.g. *It is hence important that we understand the document.*); and the (im)possibility to serve specific functions within the clause (e.g. acceptability in initial position but unacceptability as a response to a *yes-no* question: *He therefore bought it. Did he buy it? *Yes, therefore*.). Some LAs often occur in combination with conjunctions (e.g. *but also*, *and therefore*). Another important syntactic feature of LAs is their position within a clause which is not fixed but varies among initial, medial and final, though the most common is the first one and many LAs "are in fact restricted to it" (Hůlková, 2017, p. 33). Finally,

[1] There are some exceptions to this rule, such as resultative *thus*, which cannot be used within an indirect question, in contrast to resultative *therefore*: *They asked if he should *thus/therefore apologize her.*

it is typical of many LAs to be marked off by commas from the rest of the sentence (e.g. *It is, however, unlikely that they will win.*)

LAs "are primarily characteristic of the written registers" (Biber, 2006, p. 70) and particularly frequent in English academic prose (Biber, et al., 1999; Liu, 2008), where they enhance the persuasive power of the scientific knowledge negotiated with the readers. Competence in LA use allows writers to meaningfully guide readers through the discourse by "signalling how one idea leads on from another" without actually adding much propositional content (Leech and Svartvik, 2002, p. 139). However, linking sentences into paragraphs and paragraphs into whole texts can pose a challenge to professional and novice writers alike. This is possibly the reason why, as Gao (2016. p. 15) explains, most studies on the use of LAs in academic settings are based either on "ENS [English native speakers] corpora – targeting the cross-generic or cross-disciplinary differences" or "comparisons between learner and ENS corpora – aiming to elucidate the gap between native and non-native speakers' use". The former research strand generally concludes that LAs are frequently used in conversation and academic prose as opposed to news and fiction (Biber, et al., 1999; Liu, 2008), that they are more common (Peacock, 2010) and more diverse (Hůlková, 2017) in the soft rather than hard disciplines, that specific registers/genres and disciplines have their preferred LAs (Liu, 2008; Peacock, 2010; Hůlková, 2017). In turn, the latter research strand is somewhat inconsistent, reporting on LA overuse (Bolton, et al., 2002), underuse (Altenberg and Tapper, 1998), optimal use (Ishikawa, 2010), but also misuse (Chen, 2006) among learners of English, particularly those from Asia (Lei, 2012). Some contrastive works also focus on LA use by writers of academic English from different language backgrounds who can be considered as experts (Gao, 2016) or learners (Appel, 2020). Additionally, there are studies that analyse the use of LAs in academic speaking (Zareva, 2011).

An issue that seems underexplored so far is how LAs are used in selected parts of academic texts which, at least in the case of the RA, can be seen as their part-genres characterized by distinct rhetorical goals (Zhang, 2022). A notable exception to this neglect is the study by Hůlková (2017), who examined LA use in three RA sections but used different semantic categories for analysis than the ones adopted here. The general conclusion was that LAs were particularly frequent in Conclusions, less common in Introductions and rare in Abstracts. Abstracts were dominated by listing items, whereas in the other two sections the investigated categories of LAs were more evenly distributed.

This study employs Liu's (2008) taxonomy of LAs to explore text-internal variation in their use across the IMRD sections of English-medium RAs from the field of public health. The adoption of a text-internal perspective was motivated by the fact that although an academic paper constitutes an integrated whole, its distinct sections accomplish their individual discourse aims, which may influence the repertoire of linguistic devices used across the sections. Public health was chosen due to practical reasons, since the leading journals of the discipline offer open online access to published papers that typically follow the IMRD format required for the study, which helped to compile the corpus.

The contribution of this study is twofold. First, to the author's knowledge,[2] this is the first systematic analysis of text-internal variation in LA use across the IMRD sections of the English-medium RA. Given that the RA "is a not a unitary construct" (Candarli and Jones, 2019, p. 237), the results of this study will provide a deeper understanding of how the mechanisms of cohesion and coherence[3] vary to fulfil the sections' diverse communicative purposes. Second, the insights gained from this investigation may have implications for both experienced and novice writers as to how they can emphasize the discursive autonomy of each distinct part of their academic papers to facilitate the logical flow of argument in the text as a whole. To this end, the following research questions are addressed:

(1) Is there variation across the RA sections in LA use regarding their frequency and distribution by semantic category? How many of these items are section-specific and shared across the sections?
(2) Which LAs (categories and individual items) are particularly common in each section?

[2] Except for Hůlková's (2017) analysis of Abstracts, Introductions and Conclusions mentioned in section 2.

[3] In this study, coherence is a property of discourse understood as "the interpretative perception of the semantic unity and purposefulness of a text" that is "influenced and signalled by the cohesive relations holding in the text, i.e. relations between lexical items and grammatical structures which overtly connect clauses and/or clause complexes", which makes cohesion a property of text (Dontcheva-Navratilova and Povolná, 2012, p. 1).

(3) What similarities and differences can be seen in the usage patterns of the most frequent LA items in each category? How do these LAs contribute to the communicative purposes of each section?

3. Data and method

3.1 Corpus

The corpus included 200 English-medium RAs in public health published between 2019 and 2020 in four high-impact journals of the discipline indexed by SCOPUS: *The Lancet Public Health*, *Journal of Global Health*, *Environmental Health Perspectives* and *Population Health Metrics* (50 articles per journal). Only empirical RAs displaying the IMRD format (Swales, 2004) were selected, which was necessary for the subdivision of the corpus into four section-specific sub-corpora. It should be acknowledged, however, that in some of the RAs, the rhetorical moves typical of the Conclusion (i.e. summarizing the study, evaluating the study, deductions from the research) were identified in the Discussion, while in others, in a separate section. To ensure the comparability of results across the sub-corpora, if the latter was the case, the concluding sentences were coded within the Discussion section. Before inclusion in the corpus, the RAs were cleaned up to exclude abstracts, notes, citations, appendices, examples, tables, figures and bibliographies. Table 1 provides an overview of the size and composition of the corpus (947,700 words in total).

Table 1. Composition of the corpus

Sub-corpora	No. of texts	Words	Sentences	Mean sentence length
Introduction	200	129,197	4,838	25.41
Method	200	287,878	9,460	28.69
Results	200	218,264	6,281	30.79
Discussion	200	312,361	10,700	28.23

3.2 Method

In the analysis, Liu's (2008) taxonomy of LAs was employed, as it is one of the most comprehensive lists with a total of 110 items that were derived from major English grammar books (i.e., Biber, et al., 1999; Celce-Murcia and Larsen-Freeman, 1999; Carter and McCarthy, 2006) and examined systematically in the BNC across many registers. The validity of the list was confirmed by its successful use in prior studies (e.g. Lei, 2012; Gao, 2016). The taxonomy proposed by Liu (2008) is organized as follows:

(1) Additive: emphatic, apposition/reformulation, similarity comparative (36 items, e.g. *again*, *that is*, *alternatively*),
(2) Adversative: proper adversative/concessive, contrastive, correction, dismissal (29 items, e.g. *however*, *actually*, *rather*, *admittedly*),
(3) Causal/Resultative: general causal, conditional causal (16 items, e.g. *accordingly*, *otherwise*),
(4) Sequential: enumerative/listing, simultaneous, summative, transitional to another topic (29 items, e.g. *first*, *meanwhile*, *in short*, *incidentally*).

Using WordSmith v. 6 (Scott, 2012), the LAs were concordanced to calculate their frequency of occurrence and review their contextual use to verify that each was functioning as a linking adverbial. The following exclusions were made from the count, since, as suggested by Liu (2008), Peacock (2010) and Gao (2016), the listed items do not always function as LAs:

- *alternatively* (exclude e.g. *food and health were alternatively the main subject*),
- *as well* (exclude *as well as*),
- *besides* (exclude e.g. *besides weight and mood*),
- *first*, *second*, etc., next (exclude e.g. *in the first place*, *the next group*),
- *further* (functions as an LA only when followed by a comma),

- *instead* (exclude e.g. *instead of*),
- *last* (exclude e.g. *at last*),
- *rather* (exclude e.g. *rather difficult*),
- *similarly* (functions as an LA only in a sentence initial position),
- *so* (exclude e.g. *It was dark, so they had to wait*),
- *that is* (functions as an LA only when followed by a comma),
- *too* (exclude e.g. *too nervous*),
- *yet* (exclude e.g. *it is not yet known*).

The frequencies of each LA and their cumulative frequencies in each category were calculated for the whole corpus and separately for the four component sub-corpora, and subsequently normalized per 10,000 words, which is "the convention (…) for smaller corpora" (Brown, 2012).

Regarding frequency calculation, the word-based method, despite being very popular in corpus-based studies of LAs (e.g. Liu, 2008; Peacock, 2010; Gao, 2016), has been criticized by Bolton, et al. (2002, p. 172) as "fundamentally flawed" because the investigated items connect sentences rather than words. For example, considering that two texts can have the same number of words but a different number of sentences, each can potentially contain a different number of LAs. Still, as pointed out by Chen (2006, p. 118), the sentence-based method has its drawbacks as well, since LAs "can also be used in non-finite, dependent clauses", that is, below the sentence level. Another problem is the unequal mean length of the sentences in the compared sets of data. Hence, given that one of Chen's (2006, p. 118) reviewers considered both methods as valid, the word-based one has been chosen in this study to make its findings comparable with most of the previous research and to circumvent variation in the average sentence length across the RA sections (see Table 1).

4. Results and discussion

4.1 Frequency and distribution by category across the sections: General findings

Eighty different LAs with a total of 9,010 tokens were identified in the whole corpus. Of this total, the largest number was found in Discussions (4,273 tokens, 47.4%), followed by Methods (1833, 20.4%), Results (1,558, 17.3%) and Introductions (1,346, 14.9%). Individual LAs were on average found in every 73 words of Discussions, which was followed by Introductions with a connector every 95 words, Results – every 140 words, and Methods – every 157 words. Considering the distinct LA forms, as many as 75 were found in Discussions, followed by 65 in Results, 60 in Introductions and 58 in Methods.

Table 2 shows the normalized frequencies (NF) and percentages of the four LA categories in the corpus and across the rhetorical sections. Information about the raw frequency of the different (sub)categories and all the 110 individual LAs is provided in the Appendix. It can be seen from Table 2 that the contribution of LAs to the construction of textual cohesion is greatest in Discussions and least in Methods. Variation in the number and distribution of LA forms across the sections, particularly between Discussions and Methods, may be due to the fact that the former section is the most interpretative part of the RA. Therefore, it makes frequent use of cohesive ties to connect the research problem with an elaborate understanding of its implications. The Methods section, in turn, offers a precise account of the methodological approach by which a study's validity is judged, and thus it often lists the procedures that were used rather than delves into the details of the research mechanics.

Table 2. Frequency use of LA categories across the sections (per 10,000 words)

Linking adverbials	**Overall**		**Introduction**		**Methods**		**Results**		**Discussion**	
	NF	**%**	**NF**	**%**	**NF**	**%**	**NF**	**%**	**NF**	**%**
Additive	42.3	44.6	45.04	43.2	29.59	46.5	35.46	49.7	57.84	42.3
Adversative	25.0	26.4	33.74	32.4	6.18	9.7	22.90	32.1	40.46	29.6
Causal/Resultative	15.3	16.2	17.80	17.1	12.95	20.3	7.97	11.1	21.83	15.9
Sequential	12.2	12.8	7.58	7.3	14.93	23.5	5.03	7.1	16.64	12.2
Total	95.07	100	104.18	100	63.67	100	71.38	100	136.79	100

The overall frequency results of the four categories of LAs in the whole corpus, shown in Table 2, reflect those obtained by Liu (2008, p. 499) for the academic section of the BNC. The rate of LAs is comparable to the 97.72 reported by the scholar, similarly as the order of the functional categories of LAs in terms of their frequency rates, with the additive type being the most frequent in the examined corpus, followed by adversative, causal/resultative and sequential LAs. The preponderance of additive LAs in academic writing has also been reported in other studies (e.g. Lei, 2012; Ha, 2015; Gao, 2016) and suggests that researchers show deep concern for introducing "explanatory information regarding the topic of discussion" to make their discourse transparent and objective (Gao, 2016, p. 19). This is particularly the case in Results, where additive items constitute almost half of all LAs used.

The same frequency order of the four categories of LAs is found across the sections, except for Methods, where adversative LAs are the least and sequential LAs the second most common items. In fact, there is a marked presence of sequential LAs in Methods, where their percentage is the highest compared to the other sections, though their frequency is slightly higher in Discussions. A possible explanation for this might be that in the Methods section, the focus is on the presentation of the study methodology, which for reasons of clarity is often done in a sequence of steps, as exemplified by (1). The indication of more complex relationships between the discourse units, such as "contrasts, alternatives, or differences" conveyed through adversative LAs, is what the scholars are concerned with in the other RA sections (Biber, et al., 1999, p. 878), as illustrated by (2), (3) and (4). It is worth noting that the frequency of adversative LAs is the highest in Discussions, but their percentage distribution across the sections indicates that they are somewhat more prevalent in Introductions and Results.

(1) First, during data collection, supervisors must check surveys as they are completed. The surveys are then entered into a results database on the computer. (…) Next, the computerized data must be checked for completeness and accuracy. (Methods)
(2) Conversely, improvements in life expectancy after the 1970s began to be concentrated in those aged over 55, resulting in increases in longevity previously unmatched in human history (68). In fact, further life expectancy at 60 was less than 17 years in the period 1950–1955, and it currently stands at about 23 years. (Introduction)
(3) For the cases redistributed to accidental falls, the median age was 88-years and 63% were women. In comparison, for those being redistributed to road traffic accidents, the median age was 57-years and 21% were women (…) (Results)
(4) However, challenges still remain – (…) Despite this, digital technologies still offer great potential in coordinating a more precise response to outbreaks, and also shaping health outcomes. (Discussion)

The Discussion subcorpus scores the highest rates of LAs in all four functional categories, which makes this part of the RA the most abundant in logical "signposts, guiding the listener/reader through the discourse" (Chen, 2006, p. 114). The section also shows the most even distribution of the specific LA categories. A clear logical flow of ideas in Discussions lends validity to the authors' explanations and interpretations of findings, revealing their expertise and confidence in the subject matter. The next section that makes frequent use of LAs is the Introduction, which is not surprising since Swales (2004, p. 234) notes that Introductions and Discussions represent "a mirror-image reversal of" each other. Actually, only sequential items are more frequent in Methods. Well-defined logical connections enable the Introduction to effectively function "to contextualize a research study being presented in the relevant literature, claim its novelty, and present main features of the study" (Kanoksilapatham, 2005, p. 274). LAs are the least common in Methods and slightly more frequent in Results. This may be due to the fact that both sections are more focused on various aspects of the research process and its quantitative description rather than on establishing connections between more abstract and often interpretative ideas which are provided in Discussions and Introductions. It should be noted, however, that causal/resultative LAs are more frequent in Methods than in Results as well as more prevalent in this section in comparison with the other ones. This may be associated with a strong need to establish cause-and-effect relationships between the specific experimental design and the rationale for its choice, as shown in (5).

(5) Because of insufficient volume, lipid content could not be measured in NBC cord serum, so organochlorine concentrations are expressed on a wet weight basis as nanograms per gram serum. (Methods)

As can be seen from Table 3, a chi-square test[4] indicates that there is significant difference in terms of the distribution of LA categories among the sections at the 0.05 level. The standardized residuals (R), a cell-by-cell comparison of observed and expected frequencies, were calculated to reveal that eleven cells in this contingency table, namely those with an absolute value of R greater than 1.96, contributed significantly to the differences. On the basis of the information provided by R, the adversative and sequential LAs in Methods make the greatest contribution to rejecting the null hypothesis. The values of R obtained for the two LA categories indicate that there are significantly more sequential and fewer adversative LAs in Methods in comparison with the other sections. It thus seems that Methods represents the section which differs the most from the other sections. Additionally, there were more causal/resultative LAs in the section than expected, whereas in Results there were fewer such items, similarly as fewer sequential LAs, but more additive and adversative ones. In Introductions and Discussions, there were more adversative LAs than expected, but the former section used fewer sequential items, whereas the latter, used fewer additive items.

Table 3. Standardized residuals in a chi-square contingency table for the distribution of LA categories across the sections

χ^2= 543.2391, *df* = 9, *p* < 0.0001, Cramer's *V* = 0.1418		Introduction	Methods	Results	Discussion
Additive	observed Freq	582	852	774	1807
	expected Freq	599.8	816.81	694.27	1904.12
	R	-0.73	1.23	**3.03**	**-2.23**
Adversative	observed Freq	436	178	500	1264
	expected Freq	355.25	483.78	411.20	1127.77
	R	**4.28**	**-13.9**	**4.38**	**4.06**
Causal/	observed Freq	230	373	174	682
Resultative	expected Freq	217.96	296.82	252.29	691.93
	R	0.82	**4.42**	**-4.93**	-0.38
Sequential	observed Freq	98	430	110	520
	expected Freq	172.99	235.58	200.24	549.18
	R	**-5.7**	**12.67**	**-6.38**	-1.25

Concerning the 30 LA forms that were not found in the corpus at all, 12 are additive, accounting for 33.3% of all items in the category, 9 (31.03%) are sequential, 8 (27.58%) are adversative and 1 (6.25%) is causal/resultative. Following Liu (2008, pp. 501-503), one reason for their absence is that some are more typical of other registers, such as fiction (e.g. *for one thing*, *what I mean is*, *all the same*, *by the way*), news (e.g. *in the meantime*) or speaking (e.g. *what's (is) more* or *to put it another way*, *to put it bluntly/mildly*). Other ones are generally very rare, such as "the summative adverbials in the infinitive form" (e.g. *to sum up*) or the phrases *to crown it all*, *to cap it all*, *what I'm saying is* (Liu, 2008, pp. 503, 513). Still others seem to be seldom used in corpora of RAs, for instance, *above all*, *in reality*, *admittedly*, *anyway*, *at any rate*, *to begin with*, *incidentally* (Liu, 2008; Gao, 2016). Finally, some may have not been chosen due to the idiosyncratic preferences of individual writers.

4.2. Most frequent LAs in each section

Table 4 shows the top 20 most frequently used LAs in each section, which are presented in frequency order, with items occurring in all four sections left in normal font, those occurring in three sections underlined, those occurring in two sections italicized, and those occurring in one section marked in bold.

[4] VassarStats shareware was used for the statistical analysis.

It can be seen that around 90% of LAs in each list are shared across the sections (i.e. Introductions, Results, Discussions – 17 forms; Methods – 18 forms) and only around 10% are section-specific. It may be the case, therefore, that there is a high degree of text-internal similarity in the creation of textual cohesion within the RA. However, the prominence of the shared items varies across the sections, possibly because they are exploited to realize the sections' individual rhetorical purposes.

Table 4. The top 20 most frequently used LAs in the sections

Introduction		**Method**		**Results**		**Discussion**	
however	20.2	also	14.27	also	17.86	also	28.61
also	20.12	first(ly)	5.07	however	10.85	however	23.46
for example	6.19	therefore	4.16	*in/by contrast*	3.25	therefore	6.88
therefore	5.1	i.e.	3.99	i.e.	2.7	in addition (to)	6.43
thus	4.72	in addition (to)	3.36	in addition (to)	2.61	for example	5.37
despite X/this/that	4.72	then (sequential)	3.23	**similarly**	2.42	thus	5.34
furthermore	3.56	thus	3.23	therefore	2.33	despite X/this/that	4.32
in addition (to)	3.4	finally	2.81	for example	2.24	furthermore	3.84
because of it/this/that/X	2.63	however	2.67	thus	1.69	finally	3.61
i.e.	2.32	for example	1.91	**in/by comparison**	1.46	first(ly)	3.45
additionally	2.32	because of it/this/that/X	1.66	*again*	1.42	moreover	3.23
moreover	2.32	additionally	1.56	rather	1.37	second(ly)	3.04
first(ly)	2.16	second(ly)	1.45	finally		additionally	2.94
second(ly)	1.62	rather	1.32	despite X/this/that	1.37	*in/by contrast*	2.72
for instance	1.54	**next**	1.11	furthermore	1.14	because of it/this/that/X	2.65
consequently	1.47	hence	0.83	moreover	1.14	**so**	2.27
hence	1.47	furthermore	0.76	because of it/this/that/X	1.00	rather	1.95
yet	1.16	**then** (causal/resultative)	0.72	then (sequential)	0.96	**third(ly)**	2.65
rather	1.08	*again*	0.59	additionally	0.91	**nevertheless**	1.6
then (sequential)	1.08	moreover	0.55	**on the other hand**	0.77	hence	1.5

Also, the presented items account for more than two thirds of all the LA tokens in each section, namely, 85.66% in Introductions, 86.9% in Methods, 82.41% in Results and 84.2% in Discussions. It thus seems that textual cohesion in the distinct RA sections is constructed through a small set of logical connectors. Their coverage ratios for the specific LA categories are shown in Figure 1, which provides further support for the view that the writers' text-internal preferences for the specific LA categories correlate with the distinct communicative purposes of the RA sections in which they are used.

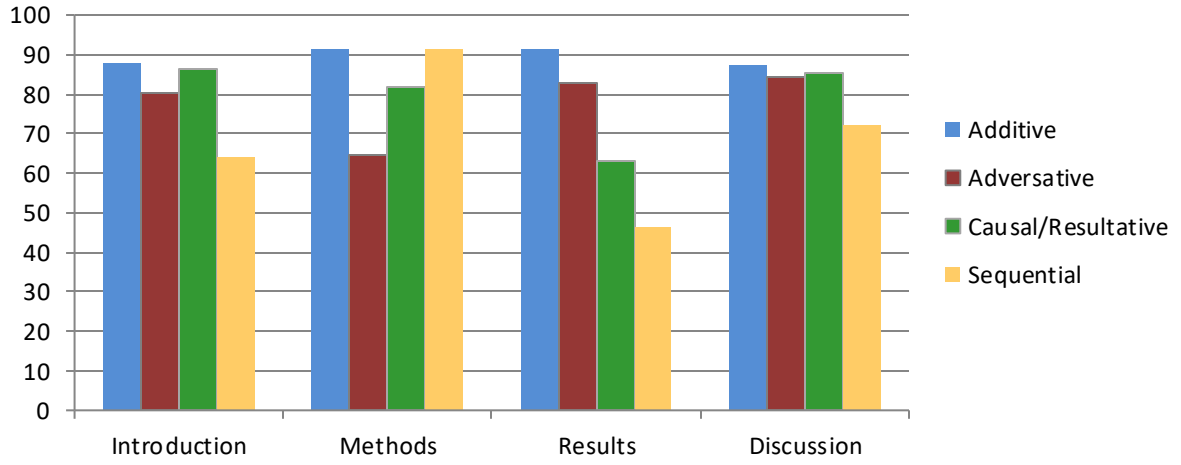

Figure 1. The coverage ratios for the specific LA categories of the top 20 most frequently used LAs in each section

Another point worth noticing is that the top 20 most frequently used LAs are generally found among the most common connectors in academic writing. For example, the most frequent item in the sections, excepting Introductions, and consequently in the whole corpus (20.62), namely *also*, was reported as reaching extremely high frequency levels in the corpora explored by Liu (2008), Lei (2012) and Gao (2016). *However*, which is the second most frequent LA in Introductions (20.2), Results (10.85) and Discussions (23.46) as well as in the whole corpus (13.8), was reported as the most common item in Chen (2006), the second most common item in Lei (2012) and Gao (2016), and the third most common item in Liu (2008). Comparison of these findings with those of other studies (e.g. Chen, 2006; Lei, 2012) confirms that professional academic writers rely heavily on a limited repertoire of LAs in their writing, which also seems to hold true for text-internal variation in LA use.

Details of the distribution of all LAs found in the corpus (N= 80) are reported in Table 5, which shows that 86.25% of the items are found in more than one section, which makes them part of the mainstream repertoire of the devices used for providing the logical flow of argument in the RAs examined. The highest number of shared (69 forms) and section-specific (6 forms) LAs is found in Discussions, whereas the lowest, in Methods (57 shared, 1 section-specific), which makes the latter seem the least coincident with the other sections in terms of creating textual cohesion by means of the target LAs. In all sections, around one third of the shared LAs belong, respectively, to the additive and adversative LA categories. In Introductions and Discussions, the third most numerous category of shared items (i.e. slightly above 20%) is the sequential one, in Methods – the causal/resultative one, whereas in Results, the same number of shared LAs is found in both these categories (almost 20%).

Table 5. Distribution information on shared and section-specific LAs

LAs found in # sections											
four	No	%	three	No	%	two	No	%	one	No	%
I, M, R, D	50	62.5	I, M, R	0	---	I, D	3	3.75	I	1	1.25
			I, M, D	1	1.25	I, M	0	---	M	1	1.25
			I, R, D	5	6.25	I, R	0	---	R	3	3.75
			M, R, D	3	3.75	M, R	0	---	D	6	7.5
						M, D	3	3.75			
						R, D	4	5.0			
Totals	50	62.5		9	11.25		10	12.5		11	13.75

Additionally, two-by-two comparisons revealed that the closest affinity was between Discussions and Results which shared 62 LAs, although only *besides*, *on the contrary*, *in any case* and *in conclusion* were exclusive to these two sections. Discussions also had 59 LAs in common with Introductions, but

only adversative *of course*, *to conclude* and *first of all* did not occur in the other sections, as well as 57 LAs in common with Methods, three of which were not found in the other sections: *in spite of this/that/etc.*, *in that case* and *afterwards*. A smaller affinity was observed between Introductions and Results, which shared 55 LAs, as well as between Methods and Results, which shared 53 LAs, but all of these items also occurred in the other sections. Introductions and Methods shared the smallest number of LAs – only 51 – none of which were unique to the two sections.

Regarding the section-specific LAs, in Discussions there were found the following items: *as a matter of fact* (additive), *not to mention*, *in such a case/cases*, *in the first place*, *all in all*, *in short*; in Results: *of course* (additive), *that is to say*, *naturally*; in Methods: *then again*; and in Introductions: *to summarize*. Due to a very low frequency of occurrence (see the Appendix), the contribution of these LAs to discourse cohesion in the distinct sections is marginal.

It should be emphasized, though, that although the sections share many high-frequency LAs, the differing frequencies of their use indicate that these items fulfil the distinct communicative purposes of each section to varying degrees. Substantial differences are observed in the use frequency of, for example, *however*, which is very frequent in Discussions but definitely underused in Methods. Four such items, each with the highest frequency in the individual LA categories, were selected for qualitative analysis to compare their usage patterns across the RA sections.

4.3. Variation in the usage patterns of the most frequent items in each LA category

In this section the usage patterns of the most frequent items in each LA category – *also*, *however*, *therefore* and *first(ly)* – are explored to see how they contribute to the sections' distinct communicative purposes.

The additive LA *also* is very common in Discussions (28.61), relatively popular in Introductions (20.12) and Results (17.86), but only half as frequent in Methods (14.27). Some interesting usage patterns of *also* are illustrated in examples (6) to (9). In sentence-initial position, which marks "explicitly the connection between units of discourse at the point when the connection is usually being made – i.e. between clauses or units larger than clauses" (Biber, et al., 1999, p. 891), it most often appears in Discussions (4.47% of all its occurrences). Similarly, its co-appearance with *but* is most common in Discussions, either as part of the *not only…but also* structure (3.46%), which allows to present two pieces of information as surprising or unexpected, or as the independent conjunction *but* plus LA *also* structure (3.13%). In turn, the combination *and also*, which simply adds one idea to another, is most popular in Results (4.35%), possibly because the section is focused on reporting the findings one by one rather than on arguing points or developing abstract theories.

(6) PTSD is often associated with other comorbid disorders, such as depression, anxiety disorders, and alcohol or drug dependency. Also, PTSD can vary over time and mimic other psychiatric disorders. (Discussion)
(7) A healthy diet is not only about avoiding what is deemed bad, but also replacing this with intake of what is deemed good. (Discussion)
(8) Social media platforms offer great potential in acting as both tools for communication and situational awareness, but also gauging health-seeking behaviors. (Discussion)

(9) Inter-individual variability between participants within each group was observed and also validated (see Figure S7 and Excel Table S5). (Results)

Apart from showing that the following element is additional, *also* is associated with making claims (Peacock, 2010, p. 25), which is often observed in Discussions when possible explanations for the findings are offered (example 10).

(10) While this could suggest, as described above, that women with more education are less likely to have abortions, and therefore to die from abortion, this association could also potentially unfold in the reverse direction: (…) (Discussion)

The adversative LA *however* combines "elements of contrast and concession", while generally indicating alternatives (Biber, et al., 1999, p. 878). Across all sections, it is most often found in sentence-

initial position, though such uses dominate in Introductions, accounting for over 80% of all occurrences of the LA item in the subcorpus. *However* encodes either the adversative/contrasting relation, as in (11), or the concessive one that can be interpreted in the sense of *although*, as in (12). According to Kortman (1991, p. 161), these are "the most complex of all semantic relations that may hold between parts of a discourse", which may explain why *however* is so popular in Discussions (23.46) and Introductions (20.2), but only half as frequent in Results (10.85) and almost nine times less frequent in Methods (2.67). The former two sections are more concerned with interpretations, justifications and the weighing of alternatives, as exemplified by (13), while the latter two are more objective and factual-oriented, as illustrated in (14).

(11) Similar to many other low- and middle-income countries, Bangladesh has made considerable improvements in maternal health over the past two decades. However, the country continues to experience some of the highest maternal mortality rates in the world. (Introduction)
(12) Finally, our study was conducted in the poorest areas and should not be representative of the whole country. However**,** all countries have the same health and preventive guidelines for the whole country. (Discussion)
(13) This could indicate evidence that the presence of abortion on the treatment list affected the number of control items reported. However, it could instead be caused by chance, or could be due to a lack of exchangeability between the treatment and control groups. (Discussion)
(14) There were 204 compounds found with Tanimoto scores >0.8; however, none were included in the Tox21 screening library. (Methods)

The causal/resultative LA *therefore*, which presents logical inferences, is most common in Discussions (6.88), relatively popular in Introductions (5.1) and Methods (4.16), and the least frequent in Results (2.33). It is often used sentence-initially, which accounts for 38.33% of all its occurrences in Methods up to even 47.05% in Results. As Gao (2016, p. 22) explains, such a clear tendency to use LAs in sentence-initial position may result from the emphasis that writers put on trying "to build an explicit linkage between two stretches of discourse", as in (15). *Therefore* is also frequently found in the phrase *and therefore*, which constitutes its most frequent two-word cluster in the whole corpus that is particularly common in Results and Discussions (around 17% of all occurrences of *therefore* in the subcorpora). The phrase either joins two independent clauses into a single sentence, and then it is often preceded by a comma, as in (16); or it simply joins two clause parts of a sentence which are of equal importance or rank, as in (17). In some sentences found in Discussions, *therefore* was used more than once (as in example 18), which allowed the persuasive power of the negotiated claims to be stressed, making them more meaningful to readers.

(15) Of the relevant studies 68 were excluded as duplicate studies, and 43 did not meet the inclusion criteria. Therefore, a total of 82 studies were included in the final review. (Results)
(16) In our current study, that would have caused inconsistencies with the applied odds ratios, and therefore we did not apply such a correction. (Discussion)
(17) Nine risk factors for any RVO were with at least three contributing data points and therefore were included for synthesis (Table 4). (Results)
(18) Presence of a non-communicable disease at baseline and therefore exclusion from the final survival models was based on self-report; therefore, misreporting might have biased results. (Discussion)

The sequential LA *first(ly)* is most common in Methods (5.07), less popular in Discussions (3.45) and Introductions (2.16) and very infrequent in Results (0.64). In all sections, the form *first* is definitely more frequent than the *-ly* form, which confirms Liu's (2008) findings. Given the numerative/listing function of *first(ly)*, its popularity in the Methods section is not surprising, where it serves to describe the steps that were followed in conducting the study. As example (19) shows, the item is often clustered with other LAs that support an orderly presentation of experimental procedures. Such chains of – mostly sequential and additive – LAs can also be found in Discussions. However, as illustrated in example (20), their role is to list the strengths of the study, not stages in the research process.

(19) First, we compared the three lower PFAS quartiles to the highest quartile, and second, we compared only the lowest to the highest quartile. We furthermore performed analyses for binary PFAS and (…) (Methods)
(20) The present study has several strengths. First, this is by far the largest study that has evaluated the association between temperature and diabetes-related hospitalization. Second, with access to a national data set covering nearly 80% of the Brazilian population and spanning 16 y, this study is representative both geographically and temporally. Moreover, our findings may also be relevant to other middle-income countries (e.g. China, India). Finally, as Brazil is a large country with significant diversity in temperatures, our results are also likely to be relevant to populations in other South American countries. (Discussion)

One interesting finding regarding the above LAs relates to the fact that in patterns involving two consecutive lexical items, they most frequently collocated with the pronoun *we*, excepting *however* that most often collocated with the definite article *the*. Only *however* was never directly preceded by *we*, but always co-appeared with the pronoun in the fixed phrase *however we*, over 73% instances of which were found in Discussions. Yet, considering the frequency of *however we* in relation to all occurrences of *however* in the specific sections, the phrase was most common in Methods, where it accounted for 9.09% of all occurrences of the LA item in the subcorpus. Concerning the other LAs, *we* functioned either as their left- or right-hand collocate, though the latter was very infrequent in the case of *also*. Interestingly, the co-occurrences of *we* with *first,*[5] *also* and *therefore* were the most common in Methods, accounting respectively for over 30%, 35% and 34% of all occurrences of each respective LA in the subcorpus. As the examples below show, writers used the LAs in combination with *we* to provide additional details concerning the research procedures. Explicit authorial presence seems particularly important in the Methods section, where it adds credibility to the scientific method chosen for the study.

(21) To test the robustness of our results, we first examined the influence of imputing outcome measurements. (Methods)
(22) For comparison purposes, we also repeated this analysis by women's educational level. (Methods)
(23) All countries had data on the number of books available to the child, except Mauritania where the information was dichotomous ("yes or no"). We therefore excluded Mauritania, (…) (Methods)

4.4. Pedagogical implications

Linking adverbials are an important aspect of language proficiency. Therefore, academic writers oriented towards publishing their research output in international journals need to learn, store and process LAs not in isolation, but together with information about the meaning they carry in the context of the specific RA sections. As the present study has shown, it is not accidental that Methods features significantly more sequentials than the other sections, since the development of an orderly research methodology is critical to undertaking a high-quality study and reaching valid conclusions. Academics should become aware that the Methods section is exceptional in its use of LAs also owing to the infrequent presence of adversative items. Adversatives seem to better find their way into argumentation in those sections where more complex semantic relations between discourse parts are developed, such as amending the main argumentation line by negating one idea in favour of another when interpreting research findings in the Discussion, or establishing links between contradictory claims made by different theorists when providing background to the topic in the Introduction. It is suggested that these and other insights into text-internal variation in LA use that can be gleaned from this study could be incorporated into academic writing courses for researchers aspiring to win membership of the international discourse community of science.

[5] *We* never co-appeared with *firstly* in the corpus.

5. Conclusion

This study has investigated variation in the use of linking adverbials across the rhetorical sections of English-medium research articles in public health. The results indicate that textual cohesion in the sections is largely constructed through a small set of LAs, but their differing frequency and distribution by semantic category reflect the distinct communicative purposes of each section. It was also found that Discussions employ more LAs, in terms of both shared and section-specific items than the other sections, Methods in particular. Although additive LAs are the most common across all sections, they preponderate in Results, whereas sequential and causal/resultative LAs are preferred in Methods, which in turn tend to underuse adversative items in comparison with the other sections. The results also indicate that the sections share many high-frequency LAs, which however fulfil the individual communicative purposes of each section to varying degrees. Detailed qualitative analyses of the most frequent LA items in each category – *also*, *however*, *therefore* and *first(ly)* – show that the differing ways in which they are exploited reflect the sections' individual rhetorical demands.

This study is not without limitations, particularly those relating to isolated instances of omissions or inaccuracies involved in the identification and classification of LAs. Also, the Chi-square test that was conducted to assess whether the distribution of LA categories differs significantly across the sections, though popular in corpus linguistics, is criticized for being invalid in corpus-based studies of lexical variations (see Bestgen 2017). The main reason is its sensitivity to large sample sizes and the assumption it is based on – that data points are independent of one another, which is rarely the case in corpus data that often have a nested structure or come from the same authors (see Gries, 2015; Lijffijt, et al., 2016). The observed frequencies do indicate that LAs are used differently across the RA sections, as also transpires from the dissimilar phraseology of the four items selected for qualitative analysis. Yet, caution is needed when considering the statistical significance of the reported disparities, especially that the value of Cramer's V indicates a weak effect size.

Nevertheless, it is believed that the reported findings may have pedagogical implications. They can inform the design of materials that can be used to raise awareness among professional and novice English writers of text-internal variation in constructing text cohesion within the RA. Extensive knowledge of how LA usage patterns vary across the rhetorical sections to serve the changing micro-purposes within the research paper could assist scholars in advancing clearer and more compelling arguments in their academic writing, thus improving their chances of publishing internationally. Future research can extend the present study by exploring variation in LA use within the academic texts of other disciplines or by focusing on hybrid RA parts, such as combined Results-Discussion sections. To refine our knowledge of how LAs are connected to different rhetorical purposes of RA sections, qualitative analyses of individual LA items are also needed both in different disciplines and in other rhetorical sections.

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Appendix. Frequency and distribution of LAs by subcategory (raw numbers)

Linking Adverbials	Overall	Introduction	Methods	Results	Discussion
Additive	**4015**	**582**	**852**	**774**	**1807**
Emphatic	***3083***	***424***	***626***	***568***	***1465***
above all	------	------	------	------	------
additionally	187	30	45	20	92
again	61	3	17	31	10
also	1955	260	411	390	894
as I/they/you say	------	------	------	------	------
as well	30	2	10	11	7
as a matter of fact	1	------	------	------	1
besides	3	------	------	1	2
in addition (to)	399	44	97	57	201
further	54	8	8	5	33
furthermore	213	46	22	25	120
moreover	172	30	16	25	101
not to mention	2	------	------	------	2
of course	2	------	------	2	------
to crown it all	------	------	------	------	------
to cap it all	------	------	------	------	------
too	4	1	------	1	2
What's (is) more	------	------	------	------	------
Apposition/Reformulation	***762***	***144***	***205***	***139***	***274***
i.e.	244	30	115	59	40
that is	30	5	10	7	8
that is to say	1	------	------	1	------
in other words	12	2	2	6	2
for example	352	80	55	49	168
for instance	83	20	11	9	43
for one thing	------	------	------	------	------
namely	40	7	12	8	13
to put it another way	------	------	------	------	------
to put it bluntly/mildly	------	------	------	------	------
what I'm saying is	------	------	------	------	------
what I mean is	------	------	------	------	------
which is to say	------	------	------	------	------
Similarity Comparative	***170***	***14***	***21***	***67***	***68***
alternatively	13	1	1	2	9
by the same token	------	------	------	------	------
correspondingly	3	------	1	1	1
likewise	33	5	4	11	13
similarly	121	8	15	53	45
Adversative	**2378**	**436**	**178**	**500**	**1264**
Proper adversative/Concessive	***1536***	***302***	***95***	***275***	***864***
at the same time	15	3	5	3	4
however	1308	261	77	237	733
nevertheless	71	9	5	7	50
nonetheless	26	2	------	2	22
of course	3	1	------	------	2
then again	1	------	1	------	------

though	62	11	5	14	32
yet	50	15	2	12	21
Contrastive	***407***	***48***	***29***	***149***	***181***
actually	23	4	6	2	11
as a matter of fact	------	------	------	------	------
conversely	39	8	2	17	12
in/by comparison	67	5	7	32	23
in/by contrast	178	13	9	71	85
in fact	52	10	1	10	31
in reality	------	------	------	------	------
on the other hand	48	8	4	17	19
Correction	***172***	***21***	***43***	***36***	***72***
instead	20	7	5	2	6
on the contrary	9	------	------	4	5
rather	143	14	38	30	61
Dismissal	***263***	***65***	***11***	***40***	***147***
admittedly	------	------	------	------	------
after all	------	------	------	------	------
all the same	------	------	------	------	------
anyhow	------	------	------	------	------
anyway	------	------	------	------	------
at any rate	------	------	------	------	------
despite X/this/that	228	61	5	27	135
in any case	3	------	------	1	2
in spite of this/that/X	5	------	1	------	4
still	27	4	5	12	6
Causal/Resultative	**1459**	**230**	**373**	**174**	**682**
General causal	***1363***	***220***	***336***	***158***	***649***
accordingly	26	------	11	9	6
as a consequence (of)	20	5	3	3	9
as a result (of)	54	11	9	9	25
because of it/this/that/X	187	34	48	22	83
consequently	67	19	12	11	25
in consequence	3	1	------	1	1
hence	100	19	24	10	47
naturally	1	------	------	1	------
so	95	4	16	4	71
therefore	452	66	120	51	215
thus	358	61	93	37	167
Conditional causal	***96***	***10***	***37***	***16***	***33***
all things considered	------	------	------	------	------
in such a case/cases	3	------	------	------	3
in that case	2	------	1	------	1
otherwise	36	1	15	10	10
then	55	9	21	6	19
Sequential	**1158**	**98**	**430**	**110**	**520**
Enumerative/listing	***1060***	***86***	***427***	***93***	***454***
afterwards	5	------	4	------	1
eventually	13	3	1	------	9
first(ly)	281/15	24/4	144/2	14	99/9
first and foremost	------	------	------	------	------

first of all	5	1	------	------	4
in the first place	1	------	------	------	1
to begin with	------	------	------	------	------
second(ly)	147/17	16/5	40/2	4/2	87/8
third(ly)	72/11	4/2	14	2/2	52/7
fourth(ly)	35/3	------	7	2	26/3
finally	235	11	81	30	113
last(ly)	15	0/1	5/2	1	9/12
last of all	------	------	------	------	------
next	49	1	32	15	1
then	141	14	93	21	13
Simultaneous	***25***	***5***	***0***	***13***	***7***
at the same time	10	3	------	3	4
in the meantime	------	------	------	------	------
meanwhile	15	2	------	10	3
Summative	***73***	***7***	***3***	***4***	***59***
all in all	1	------	------	------	1
in a word	------	------	------	------	------
in conclusion	38	------	------	1	37
in short	1	------	------	------	1
in sum(mary)	20/2	2/1	3/0	2/1	13/0
to conclude	9	2	------	------	7
to sum up	------	------	------	------	------
to summarize	2	2	------	------	------
Transitional to another topic	***0***	***0***	***0***	***0***	***0***
by the by	------	------	------	------	------
by the way	------	------	------	------	------
incidentally	------	------	------	------	------