



A multi-dimensional analysis of conclusions in research articles: Variation across disciplines

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ABSTRACT

Research article sections, particularly the introductions, have received considerable scholarly attention over the years. However, linguistic strategies in the conclusion sections of research articles (RAs) remain under-researched. In light of this, we aspired to add to such scholarship by examining linguistic variation in RA conclusions across six disciplines. A multi-dimensional analysis of conclusions was conducted by using Biber's (1988) dimensions. Analytical results indicate that the conclusion writers in natural sciences and social sciences exhibit significant differences along D1 (Involved and Informational Discourse), D2 (Narrative and Non-Narrative), and D4 (Overt Expression of Persuasion). The findings suggest that conclusions from all six disciplines tend to use possibility modals (e.g., *can*) and prediction modals (e.g., *will*) to evaluate studies and to refer to future research directions. Additionally, conclusions in education and sociology tend to contain more interaction and persuasion elements than those in natural sciences, indicating a more human-centered research approach to soft sciences. On the other hand, conclusions in natural sciences are more information-condensed and procedure-oriented than those in social sciences. This study adds to the growing knowledge of RA sections and contributes to the study and teaching of EAP and ESP.

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1. Introduction

1.1. General introduction

A growing academic interest in research article (RA) sections has given rise to a plethora of studies on the linguistic and discursive features of these RA subgenres (Sheldon, 2018; Swales, 1990; Ye, 2019). Numerous studies have been conducted on both the linguistic and the macro-structure of RAs across different disciplines and cultures (e.g., Hirano, 2009; Loi, 2010; Samraj, 2002; Sheldon, 2011; Yin et al., 2021). Notably, Swales' (1990) CARS (Creat a Research Space) model breaks fresh ground for subsequent explorations of the move structure of different RA sections, among which the introduction section in particular has attracted more scholarly attention than any other RA sections (e.g., Samraj, 2002, 2005, 2008; Cortes, 2013; Hirano, 2009; Loi, 2010; Lu et al., 2018; Sheldon, 2011; Wang & Yang, 2015). Researchers have also attempted to investigate important linguistic representations and communicative functions of RA sections such as methods (Martínez, 2003), literature reviews (Kwan et al.,

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2012), results (Bruce, 2009), and discussions (Basturkmen, 2012; Le & Harrington, 2015). Calls for addressing issues like ‘evolving nature of genre’ (Askehave & Swales, 2001) and the gradual change in the macrostructure of RAs have urged scholars recently to revisit rhetorical structures (e.g., Lin & Evans, 2012; Jin et al., 2020; Sheldon, 2011; Ye, 2019) and linguistic features in RA sections (e.g., Cortes, 2013; Jin, 2018; Moreno, 2021; Yin et al., 2021). Although continuous effort has been made to reveal the linguistic features of RA sections, scholars still claim that more research must be conducted to explore the linguistic realization of RA sections (Cortes, 2013).

The classical IMRD (Introduction-Method-Results-Discussions) model of research articles demonstrates that the discussion and conclusion are often deemed inseparable as the closing section (Swales, 1990), and thus potentially undermines the distinctive and important communicative function of the conclusion as an independent subgenre. Many researchers asserted that the IMRD model has never been the default model for research articles and that it is important to view conclusions as well as literature review sections as independent sections (Hsieh et al., 2006; Amnuai & Wannaruk, 2013). The findings of recent studies indicated that RA conclusions could also be essential. Yang and Allison (2003) investigated the macrostructure of research articles and discovered that 13 out of 20 RAs they examined had conclusion sections. Also, they pointed out that the discussion and conclusion sections are not the same, with discussions emphasizing “commenting on specific results” and conclusions focusing more on “overall findings and evaluation of the study” (p.379). Hence, they proposed that the conclusion (C) section may stand as an independent section rather than being merged with the discussion (D) section. Their findings are illuminating in promoting studies on the conclusion as an independent section and inspiring in revealing its distinctive communicative purposes. Hsieh et al. (2006) stressed the “possible overlooking” of the L (literature review) and C sections. Lin and Evans (2012) further pointed out that “IMRD is not an especially prevalent pattern in contemporary RA writing, so strict adherence to such a structure when conducting move-based or linguistic analysis is likely to result in incomplete or unrepresentative findings” (p.151). Their study also illustrated that out of 433 empirical RAs from high-impact journals in 39 disciplines, ILM[RD]C (Introduction-Literature Review-Method-Results and Discussion-Conclusion) is the most commonly used structural pattern. Their study also showed that C, L, and [RD] are important independent sections in contemporary RAs. In this regard, they called for more scholarly attention to the C, L, and [RD] sections of journal articles, all of which play important roles in modern academic writing. Conclusion, in particular, as an independent section may facilitate the realization of the author’s communicative purposes in emphasizing the research results, the research contribution, and future directions. These communicative purposes reinforce the crucial role of RA conclusions. Therefore, driven by the crucial communicative purpose of RA conclusions as well as scholarly overlooking of this section, this study focuses mainly on the linguistic variation of RA conclusions across natural and social sciences to add to the current literature of RA subgenres.

Disciplinary variation in academic writing is also among one of the most important topics in the EAP and ESP area (Hyland, 2004, 2005, 2008; Basturkmen, 2012; Biber, 1988; Cortes, 2004; Gao, 2016; Harwood, 2005; Hyland & Jiang, 2018; Hyland & Tse, 2005; Lin & Evans, 2012). Cortes (2004) investigated lexical usage in two disciplines between published and student writing, where common lexical bundles in different disciplines and discipline-specific bundles are both present. Her study also showed that lexical bundles in history and biology involve different structural groups. Hyland (2004, 2005, 2008) explored the social and rhetorical practices of academic communities in different disciplines and suggested that writers in various disciplines may utilize different resources to construct their academic writing. Moreover, Egbert (2015) examined disciplinary differences in published academic writing. His research indicated that writers in biology tend to use empirical data as supporting evidence, whereas writers in history rely much more heavily on their own interpretation and rhetoric. Previous studies on disciplinary variation provide a solid foundation for the current study to examine the RA conclusions from different academic disciplines.

1.2. Multi-dimensional analysis and research objectives

To explore the linguistic variation within RA conclusions across disciplines, we opted for multi-dimensional analysis (MDA), which combines quantitative and qualitative analysis. The MDA approach is pioneered by Biber (1988) to investigate register variation, which allows the exploration of microscopic as well as macroscopic linguistic variation. In addition, it is a powerful tool to examine the extent to which specific linguistic features vary across texts (Friginal & Weigle, 2014). A good number of MD studies have demonstrated the existence of ‘universal dimensions of variation’ in language (Friginal & Weigle, 2014: 82) and have indicated that MD analysis applies to any corpora (Forchini, 2012). MD analysis has been applied in examining linguistic variation across different cultural backgrounds. For example, Friginal and Mustafa (2017) analyzed linguistic variation in abstracts published in the United States and those published in Iraq. Furthermore, Cao and Xiao (2013) looked at the variations in the abstracts written by native English writers and Chinese writers from twelve different academic disciplines. Both studies demonstrate that native English writers tend to use more involved language features than Iraqi abstract writers and Chinese abstract writers. These two studies shed light on informing both native and non-native speakers in terms of writing research article abstracts across disciplines. The findings of these studies also revealed how cultural differences could affect microscopic linguistic features.

MD analysis has also been performed across various disciplines (Gray, 2013; Hardy & Römer, 2013; Gardner, Nesi, & Biber, 2019). Gray (2013) conducted an MD analysis of linguistic variations in six disciplines by examining seventy lexical and grammatical features in 270 research articles. Consequently, she identified new dimensions of linguistic variation and discovered that these variations are not only associated with disciplinary norms but are also affected by the different purposes

of research. Generally, philosophy authors prefer using cognition nouns (e.g., theories and concept) to develop their arguments and logic to explore the human experience with an argumentative purpose. On the other hand, physics and biology conclusions use more information-condensed language, such as noun phrases, prepositions, and passive structures, to objectively present scientific facts with an 'informational purpose' (p.160). Gray's (2013) study provides insight into the disciplinary variation in academic writing. Furthermore, Gardner et al. (2019) explored linguistic differences across disciplines, language proficiency levels, and genre types through a new MD analysis of the British Academic Written English (BAWE) corpus. Their study found disciplinary differences in the use of tenses among writers. For example, the present tense is more common in philosophy and mathematics, while the past tense is more prevalent in history and classics. The findings of their study are useful for facilitating the teaching of a common academic core. Thus, the previous studies have shed light on disciplinary variation and provide a good starting point for understanding the research value of examining disciplinary variation through MD analysis. Research has also been conducted on the linguistic variation of different sections of research articles, such as abstracts (Cao & Xiao, 2013; Friginal & Mustafa, 2017) and discussion sections (Jin, 2018). In his study of engineering discussion sections, Jin (2018) found that hedges and boosters are key elements of how researchers present themselves in discussion sections, particularly expert writers who tend to use strategic language devices to indicate their epistemic stance.

Overall, studies have shown that MD is an effective method for examining variation and is considered a dominant approach for analyzing register variation (Gardner et al., 2019, p.647). In addition, this approach allows scholars to examine linguistic variation that is difficult to distinguish between related disciplines (Thompson et al., 2017). Considering the essential role of the conclusion sections in RAs and the crucial methodological value of MDA, and in response to suggestions for further research on disciplinary variation from previous studies, the current study first examines the linguistic features that characterize conclusion sections in research articles and then explores linguistic variation across and within disciplines. More specifically, we will address the following research questions:

1. What are the distribution patterns of linguistic features in the conclusion sections of research articles in the natural and social sciences when using Biber's (1988) dimensions?
2. How do the linguistic features of research article conclusions vary across different disciplines and fields?

2. Methodology

2.1. Corpus description

To achieve our research objectives, we collected 3,000 RA conclusions. These include 1,500 conclusion texts for the natural sciences and 1,500 conclusion texts for the social sciences. These conclusions have been drawn from empirical research articles published from 2007 to 2018 (the year we collected the texts) across six disciplines. The journals included in the corpus are international peer-reviewed journals indexed in either the SCI (Science Citation Index) or SSCI (Social Sciences Citation Index) databases. These two databases provide a wide selection of journals from various disciplines which are highly respected in their fields.

Additionally, the Journal Citation Report supported by Clarivate Analytics was consulted. The report presents the impact factors of each journal in a particular field. The impact factor of a journal suggests that it has a high citation rate in the field, which may be indicative of the journal's high quality. Upon receiving the 2017 impact factor of each discipline, we reviewed the journals in each field, starting from the journal with the highest impact factor in that field. In the meantime, research articles in the journal were checked, and articles with complete IMRDC or IM[RD]C structure were downloaded. In selecting the RA conclusions, the conclusion section included has the conventional functional heading of 'Conclusion(s)'. The research articles with the last section titled 'Discussion and Conclusion' were removed. Ultimately, 31 journals from six disciplines were incorporated into our corpus. The list of the journals is provided in Appendix A. The final corpus comprises six disciplines, including applied linguistics, sociology, and education from the social sciences and cell biology, engineering, and physics from the natural sciences.

Journal articles were downloaded as .pdf files and saved as .txt files, and the conclusion sections were then extracted and saved as .txt files. Each text was stored independently, titled with information such as publishing year, knowledge field, and serial number. For example, ConL.HS_2007BioS_001 indicates that the text belonged to the natural science field and was published in 2007 from Biosystem. Sublime Text software was used to check the spelling, join the broken sentences, and find non-ASCII characters. We finally chose 500 texts from each discipline to be included in the corpus. The corpus of natural science conclusions (CCNS) contains 1,500 texts and 345,139-word tokens. Moreover, the conclusion corpus of social sciences (CCSS) includes 1,500 texts and 536,134-word tokens. Table 1 provides detailed information about the corpus.

Table 1
Corpus Description of CCSS and CCNS.

Corpus	Disciplines	Texts	Words
Conclusion Corpus of Social Sciences (CCSS)	Applied linguistics	500	163,102
	Sociology	500	199,575
	Education	500	173,457
	Sub-Total	1,500	536,134
Conclusion Corpus of Natural Sciences (CCNS)	Cell Biology	500	86,316
	Engineering	500	160,834
	Physics	500	97,989
	Sub-total	1,500	345,139
Total		3,000	881,273

2.2. Procedure

The purpose of this study is to investigate the linguistic variation in conclusion sections across academic disciplines. An analysis of the co-occurring linguistic features can be achieved using Biber's multi-dimensional analysis. For the present study, we used the Multi-dimensional Analysis Tagger (MAT) developed by Nini (2019), which replicates Biber's (1988) tagger to analyze the corpora. The tagger is based on 67 linguistic features selected from Biber's (1988) study.

The MAT first tagged the entire corpora using the Stanford Tagger for the preliminary tagging and then calculated the dimension scores for each text. It then generates frequency features for each text based on the z-scores and dimensional plots of each discipline, which provides a much more comprehensive picture of the texts. It should be noted that the MAT does not produce an exploratory factor analysis, but rather determines the extent to which a corpus corresponds to Biber's (1988) dimensions (Crosthwaite, 2016). The five dimensions of Biber's (1988) study are summarized in Table 2, adapted from Nini (2019).

Table 2
Descriptions of Dimensions (Adapted from Biber, 1988 and Nini, 2019).

Dimensions	Description
Dimension 1	Involved vs. Informational discourse
Dimension 2	Narrative vs. Non-Narrative Concerns
Dimension 3	Context-Independent Discourse vs. Context Dependent Discourse
Dimension 4	Overt Expression of Persuasion
Dimension 5	Abstract and Non-Abstract Information
Dimension 6	On-line Informational Elaboration

The MAT has been investigated for reliability and applicability by Nini (2019) and has also been used by other researchers that contribute to the scholarship with some very illuminating findings (e.g., Crosthwaite, 2016; Ren & Lu, 2021). It has been demonstrated that Biber's (1988) multi-dimensional model can also be applicable to new data sets (Nini, 2019). For example, Crosthwaite (2016) used the MAT to examine students' writings; Ren and Lu (2021) adopted the MAT to explore narratives in corporate reports. For their study of corporate annual reports, Bu et al. (2020) also combined MD analysis with rhetorical structure theory. In previous studies, the MAT has proved to be applicable and useful for studying linguistic variation.

Therefore, we started with the 67 lexical-grammatical features identified by Biber (1988) and used the MAT to annotate natural and social sciences corpora with these features. The frequency counts of all linguistic features are normalized to 100 words to account for differences in text length. According to Nini (2019), the MAT produces a tab-delimited file titled 'corpus_statistics.txt' with frequency counts, as well as a tab-delimited file including the z-scores of the linguistic variables. Besides, a tab-delimited text file containing the dimension scores is displayed. It is interesting that the MAT also produces a graph that illustrates the location of the analyzed corpus with respect to Biber's (1989) eight text types. The statistics and the z-scores produced for the two corpora and each discipline were imported into SPSS for further statistical analysis.

An MD analysis was performed to investigate the linguistic variation between natural sciences and social sciences as well as the variation across the six disciplines. Using the statistical results generated by the MAT, we then used independent *t*-tests to determine any significant differences in linguistic variation in conclusions across disciplines along the six functional dimensions. A one-way ANOVA was conducted to investigate if there were significant differences across the six disciplines along the dimensions. In the following section, we chose to present our results along D1, D2, D3, D4, and D5.

3. Results and discussions

This section presents descriptive statistics for each dimension, followed by inferential statistics that contrast natural and social sciences, and then each of the six disciplines. For each dimension, explanations, excerpts, and discussions are included.

Even though our data are not identical to the data in Biber (1988), the figure generated by the MAT indicated that the closest category of both corpora compared to Biber's study (1988) is learned exposition, which has the characteristic of being highly information condensed. This corresponds well with the academic nature of the RA conclusion section, which relates to the presentation of overall findings.

Table 3 summarizes the dimension scores and *t*-test results for the natural and social science conclusion corpora, along with the genres they are most similar to on each dimension compared to Biber's (1988) dimensions. Table 3 indicates that, except for D4, conclusion texts from the two corpora correspond to the same type of texts as those identified by Biber (1988). Meanwhile, both corpora have relatively large standard deviations for the five dimensions values. These results have shown that the conclusion sections may vary within the same knowledge field with regard to their linguistic features, displaying the disciplinary variation across these six disciplines. Furthermore, Table 3 also displays the results of *t*-tests between the two corpora along the five dimensions. It appears that conclusion sections in the two corpora differ significantly in their scores on D1, D2, D4, but not on D3 and D5. One-way ANOVA tests have demonstrated that the six disciplines are significantly different along the dimensions ($p < 0.001$) (see Appendix B for the results of the one-way ANOVA). Next, we examined the results for each dimension across the six disciplines in more detail.

Table 3

T-tests for six-dimension scores between natural and social science conclusion corpora.

	Natural Science Conclusion Corpus			Social Science Conclusion Corpus			<i>t</i>	<i>df</i>	<i>p</i>
	Mean	SD	Closest Genre	Mean	SD	Closest genre			
D1	−22.94	6.4	Official documents	−18.83	6.7	Official documents	−17.07	2998	<.001*
D2	−4.04	2.82	Broadcasts	−3.33	2.69	Broadcasts	−7.01	2998	<.001*
D3	8.74	4.64	Official documents	8.91	4.68	Official documents	−0.98	2998	.327
D4	−3.03	4.32	Broadcasts	−0.94	4.23	Press reportage	−13.39	2998	<.001*
D5	5.75	5.63	Academic prose	5.29	5.09	Academic prose	2.33	2998	.020

*Significant at $p < 0.01$.

Table 4 gives insights into the variation in dimension scores for the six disciplines between the two corpora. The six disciplines have scores of the same polarity for all five dimensions. All six disciplines have low scores on D1, high scores on D3 and D5, featuring the informational condensed, context-independent, and formal features of academic writing, which also conforms to the general mean score for the two corpora as shown in Table 3.

Table 4

Mean and SD for conclusion corpora across six disciplines.

	Engineering		Physics		Cell Biology		Education		Linguistics		Sociology	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
D1	−20.06	5.45	−24.61	5.21	−24.13	7.51	−17.77	6.48	−19.88	6.98	−18.83	6.47
D2	−4.26	2.16	−3.85	2.76	−4.00	3.38	−3.54	2.66	−2.99	2.81	−3.47	2.59
D3	8.77	4.29	8.92	4.49	8.54	5.10	9.56	4.67	7.36	4.28	9.81	4.70
D4	−1.10	4.18	−4.83	3.21	−3.17	4.62	−0.16	4.29	−1.47	4.26	−1.19	4.03
D5	6.22	4.76	5.63	5.09	5.42	6.80	4.73	4.94	5.88	5.31	5.28	4.96

3.1. Dimension 1: involved discourse vs information condensed

According to Biber (1988), the negative pole of Dimension 1 represents discourse with information-condensed nature and “is carefully crafted and highly edited” (p.115). The dimension scores of natural science conclusions and social science conclusions (−22.94 and −18.83 respectively) along D1 indicate that both corpora reveal highly information condensed nature although there is significant variation between the two corpora ($p < 0.001$), showing that the natural science conclusion corpus is further along the information condensed pole.

A further look at the mean plots (Figure 1) and the ANOVA tests of the six disciplines along D1 reveals that physics and cell biology involve significantly more descriptions and are more information-condensed than engineering conclusions within natural science. Moreover, within the social science fields, conclusions in linguistics are significantly different from education and sociology ($p < 0.001$), showing more descriptive language.

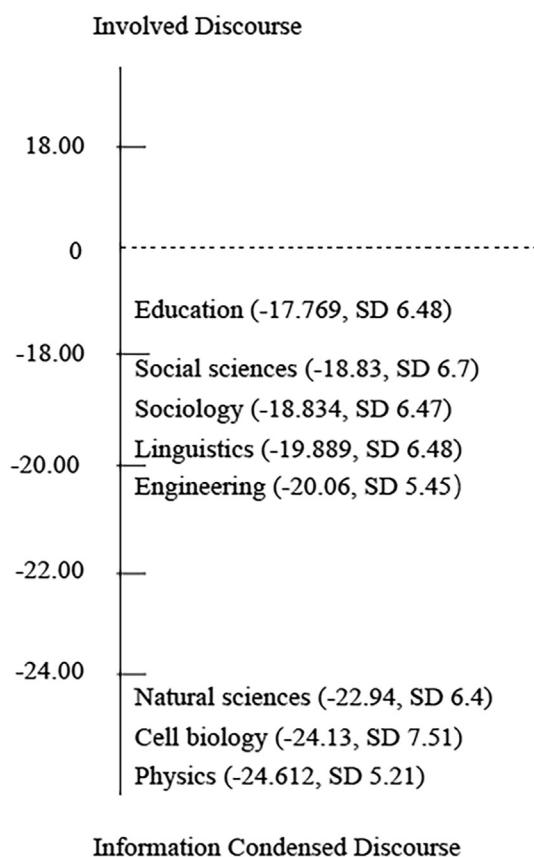


Figure 1. Dimension Scores along Dimension 1 for the Six Disciplines Analyzed in this Study.

The primary linguistic characteristics of the negative end along D1 are the frequent use of nouns, prepositional phrases, high type/token ratios, and longer words (Biber, 1988), all of which contribute to the highly informational nature of social and natural sciences. According to the z-score generated, both corpora have long word length, overused conjuncts (e.g., *furthermore*, *however*), **nouns**, and **attributive adjectives**. Especially when referring to the overall work and methods, natural science writers adopted **nouns** and **attributive adjectives** to pack up information for the target reader (Example 1). Nevertheless, natural science conclusions contain many more nouns than social science conclusions (2.93 vs. 1.89), reflecting a more informational condensed nature.

- (1) In this **work**, the **adsorption energies** of **mono-branched alkanes** in **HY** and **HZSM-5** have been theoretically investigated by **DFT calculation** using **mGGA-M06-L function**. The **8T** and **48T (66T) models** representing **local** and **framework structures**, respectively, were built. Compared with **acid strength**, the **confinement effect** plays a more **important role** in **adsorption**. (ConLHS_2017ASS_009. Physics).

The significant differences between social science and natural science conclusions may be due to several linguistic elements found in social sciences that indicate the positive end along D1. Social science conclusions have a positive load on *wh*-clauses (0.12), possibility modals, and sentence relatives, suggesting social science conclusion writers' way of 'expressing attitudinal comments.' (Biber, 1988: 107). Specifically, conclusions in education (0.28) and sociology (0.15) have positive loading on *wh*-clauses, which indicates a 'primary affective function' (Biber, 1988:107) (Example 2) and evaluation by the writers. Conclusion writers from sociology use **first personal pronouns**, **nouns** (*suggestion*), **[that-clause]**, and **[wh-clause]** sentence fragments to interact with audiences and to provide an implication of the research (Example 2). While writers in education use **first personal pronouns**, **nouns**, and **[that-clause]** to present and evaluate the overall findings (Example 3).

- (2) **We** have also provided related **suggestions [that assist researchers and teacher educators] [who use the same strategy to promote teachers' online knowledge-sharing...]** (ConLSS_2009TTE_002. Sociology).
- (3) **Our study** contributes to the scientific **literature** in four **ways**...Second, **our models** posit, and the **results** support, **[that these characteristics of teaching, in addition to positive emotions and stress, are feeble predictors of perceived control]**. (ConLSS_2017TTE_007. Education).

Furthermore, social science conclusions use more emphatics than natural science conclusions (0.09 vs. -0.82). Sociology conclusions in particular are more likely to use emphatics (-0.03) to give a personal evaluation on the statement or findings, as 'most' in Example 4, expressing writers' positive attitude on the findings. Those attitudinal markers are preferred in softer

disciplines, allowing writers to ‘intrude into their texts’ to establish themselves as insiders and experts in the field (Hyland, 2004: 25) and to negotiate knowledge with readers (Hyland & Guinda, 2012). Besides, social science conclusions tend to use private verbs more frequently than natural science conclusions (−0.23 vs. −0.41).

It was also found that conclusion texts in education along D1 use [WH-clauses], **emphatics (more, most)**, **possibility modals (may)**, and **adjectives (better, effective)** more frequently than other disciplines (Example 5). As shown in Example 5, the use of emphatics, adjectives, and possibility modals may contribute to the positive evaluation of the study.

- (4) **We** find that both peer groups have a significant influence on women's fertility. preferences. Peers have the **most profound** impact on the fertility preference for two to three children. (ConL.SS_2017SIR_009. Sociology).
- (5) These future studies **may** help us **better** understand **[how teachers share knowledge online and determine more effective ways to help them share teaching-related knowledge.]** (ConL.SS_2009TTE_002. Education).

As a result, Dimension 1 provides evidence that conclusions from natural and social sciences are informationally condensed, indicating the general academic nature and densely packed information of conclusions (Gardner et al., 2019). This finding also accords with Gray (2013, 2015) and Biber and Gray (2013) that the information condensed way of academic writing has been adopted more frequently in scientific writing than in non-science writing. On the other hand, social science conclusions tend to be written in a more interactive way than science conclusion sections. The finding further demonstrates that conclusions with a highly negative dimension score along Dimension 1 can still use positive language features, which is in accordance with Gray (2015). Taken together, the loadings of different disciplines along D1 indicate that the primary purpose of the conclusion writers is to provide information (Biber, 1988). However, in addition to objectively reporting the overall findings of a study in conclusion sections, writers use positive linguistic features to construct their comments on those findings to achieve the purpose of evaluating, persuading, and interacting. In this manner, they are able to realize their intention to promote their research in the final part of the research article.

3.2. Dimension 2: narrative vs. non-narrative concerns

According to Biber (1988), the positive pole of Dimension 2 means that the corpus is narrative, while the negative pole means that it is non-narrative. The conclusion corpora of natural sciences and social sciences both have negative weights (−4.04 vs. −3.33) along D2. The result indicates that the conclusions in both corpora have a non-narrative orientation, which is consistent with what was expected of academic writing. The primary features of the non-narrative orientation are **present tense** and **attributive adjectives**, which are used for ‘more immediate reference’ (Biber, 1988:92). The description of the past studies in the conclusion sections of Example 6 uses **present tense** and **attributive adjectives**, which are indicative of a ‘descriptive discourse’ and characterized by ‘nominal elaboration’ (p.109).

- (6) Extensive studies in other **cardiovascular** disease **demonstrate** that maintenance of an **intact** and **functional** endothelium **is** important for protecting against degeneration and disease. (ConL.HS_2016MCC_0042. Cell Biology).

The independent *t*-test demonstrates a significant difference between the two corpora ($t = -7.01$, $p < .001$) with the natural sciences further along the non-narrative pole and the social science conclusions less non-narrative. It was found that social science conclusions tend to use comparatively more third-person pronouns than natural science conclusions. As pointed out by Biber (1988) that the use of **third-person pronouns** usually connects with animate things, especially humans. A further examination of conclusion texts shows that some conclusion texts in sociology present the research findings which centers around human life (Example 7). Biber (2006:204) explains that education and humanities writing have ‘a more narrative orientation’.

- (7) The results of this paper demonstrate that adolescents are privileged or. disadvantaged in **their** levels of relationship in actualization-the disjuncture between what **they** “want” in **their** ideal relationships and what **they** “get” in **their** actual relationships as a result of the structure of their friendship networks, as well as **their** position within them. (ConL.SS_2017SSR_001. Sociology).

Furthermore, **present participial clauses**, a narrative-making feature, were found to have positive weights for social science fields (0.35), as well as natural sciences (0.38). Subordinate clauses frequently appear in depicting the future research direction in the conclusion sections (Example 6) of the natural science disciplines. In the social sciences, writers tend to use the **present participial clause** and **third-person pronouns** to draw implications of the study (Example 7). The use of these linguistic features helps conclusion writers to achieve the purpose of presenting implications. The findings also correspond with Cortes (2013), who explained that the use of **third-person pronouns** and **human/animate nouns** (e.g., *human, mice, children*) allows researchers to illustrate future events (Example 8) and further ‘interpret and draw conclusions from’ (p.168) (Example 9).

- (8) While our study focuses on aging in wild type **mice**, **moving forward the field is now poised to consider the complexities of genetic alterations and the hemodynamic, environment on VEC dynamics in mouse models of human valve disease**. (ConL.HS_2016MCC_0042. Biology).
- (9) Although the present research describes a small case study, some implications can be drawn from the results. Interactive software programmes can help to focus **children's** attention on the lesson content, **allowing them to visualize the processes involved in solving on screen tasks, making their errors more easily identifiable and promoting the sharing of knowledge through listening and talking**. (ConL.SS_2010Sys_002. Linguistics).

As shown in Figure 2, all six disciplines display a non-narrative concern, suggesting the scientific nature of academic writing. Engineering conclusion texts are the furthest along the negative pole of D2, which indicates a more non-narrative concern than in other disciplines.

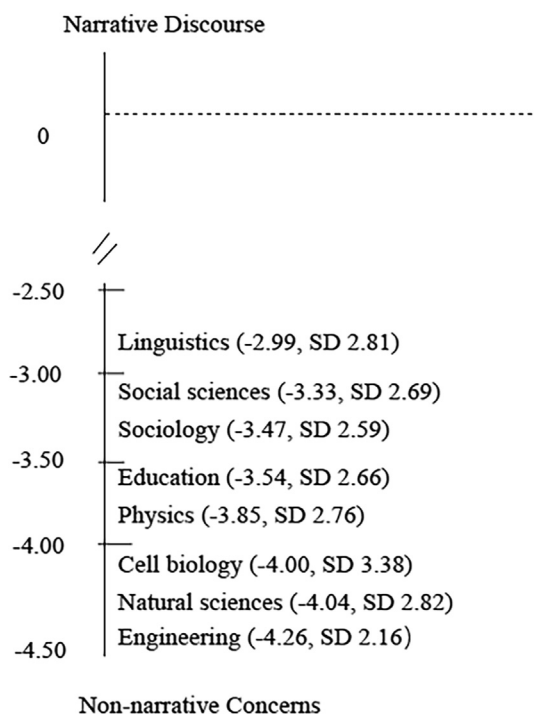


Figure 2. Dimension Scores along Dimension 2 for the Six Disciplines Analyzed in this Study.

Rather, conclusions from linguistics are closer to the positive end, possibly because narrative elements are included in linguistics. The positive features such as public verbs are more often used in the conclusion sections of social sciences than in natural sciences. The **public verbs** frequently function as markers of reported speech (e.g., *suggest*, *predict*) followed by **[that-clause]**. An investigation of the conclusions of linguistics shows that writers frequently use reporting verbs to present their overall findings of a study (Example 10).

- (10) ...the findings **suggest [that depending on the way word derivational. knowledge is operationalised, the ability to derive words is either more or less stable or increases more after level B1]**. (ConLSS_2016Sys_0011. Linguistics).

In sum, academic conclusions from the natural and social sciences tend to be non-narrative. However, social science conclusions have fewer non-narrative concerns compared with natural science conclusions. Nevertheless, conclusion texts from applied linguistics research articles use some positive features such as public verbs, third-person pronouns, and present participial clauses to identify the future research direction and implications of the study.

3.3. Dimension 3: context-independent vs. context-dependent discourse

The high score in D3 indicates a high level of 'explicit, context-independent reference' (Biber, 1988). Conclusion texts from natural sciences (8.74) and social sciences (8.91) all have positive weights in D3, in line with Biber's (1988) finding that 'all academic prose sub-genres have high scores on D3' (p.193). No significant variation has been displayed between natural and social sciences ($t = -0.98$, $p = .327$). It can be inferred that high scores in D3 are typically accompanied by low scores in D1, due to the frequent use of nominalizations in both D3 and D1. The results of the study demonstrate that conclusion texts from the six disciplines are highly context-independent. According to Biber (1988), high scores along this dimension are featured by 'text-internal reference.' The highly nominalized information and explicit referent may be related to the overall purposes of the conclusions. Writers from the six disciplines would constantly refer to information from other sections of research articles with the aim of summarizing and evaluating the overall findings.

A further examination of the six disciplines analyzed in this study (Figure 3) reveals that conclusion texts in both sociology (9.81) and linguistics (7.56) loaded positively, with sociology further along the positive end. Based on the results, it is suggested that conclusion texts in sociology ($p < 0.001$) and education ($p < 0.001$) differ significantly from conclusions in

linguistics due to the higher occurrences of WH relative clauses, pied-piping constructions, phrasal coordination, and nominalizations in sociology, especially with respect to the use of phrasal coordination (4.61 in sociology vs. 3.06 in linguistics) and nominalizations (2.66 in sociology vs. 2.03 in linguistics).

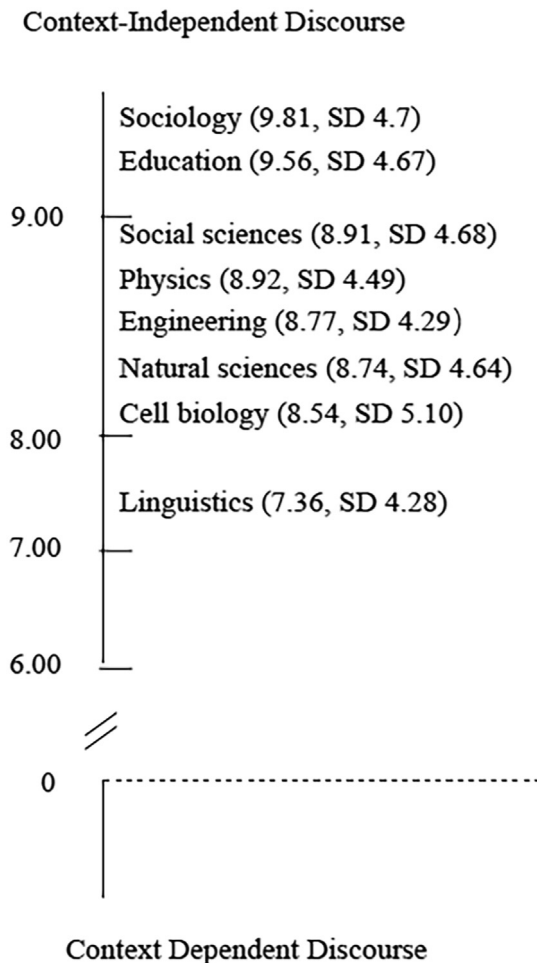


Figure 3. Dimension Scores along Dimension 3 for the Six Disciplines Analyzed in this Study.

In addition, it was found that [pied-piping constructions] (Biber, 1988) loaded positively on D3 as a primary positive feature in social sciences (0.3) (Example 11), indicating that conclusions from social sciences may be written in a more explicit and elaborated manner. In Example 11, the writer tries to convince the reader of the value of future research based on the current findings and to explain the reason for conducting the future study.

- (11) Future research is also needed to compare these three methods in applied face-to-face and online settings, as applied and online settings may represent boundary conditions [in which the psychological effects of directly-communicated rationales operate differently than expected in face-to-face laboratory settings.] (ConLSS_2017IJER_0013. Education).

Moreover, the z-scores for phrasal coordination, which is the key positive linguistic feature in D3, are relatively high in natural sciences (3.39) and social sciences (4.07). The z-scores for **nouns** are also high in both fields (2.4 in social sciences vs. 2.43 in natural sciences). The co-occurrence of phrasal coordination and **nominalizations** demonstrates that the conclusion text in both corpora tends to be informational-oriented (Biber, 1988: 110), as shown in Example 12, trying to integrate and concisely present all the research findings. However, conclusion texts from linguistics have a relatively low frequency of nominalization compared with other disciplines.

- (12) In **summary**, we have demonstrated that H2 **evolution** over Pd **nanocatalysts**. was governed by two **reaction steps** of Tafel **reaction**: H***combination** was very difficult over the **large** Pd NPs, while the rate-limiting **step** for media-sized Pd **cluster** is H2 **desorption**. Moreover, both H***combination** and **desorption** of **molecular H2** are sluggish on the **sub-nanometer Pd clusters**. (ConLHS_2017NANO_0020. Physics).

3.4. Dimension 4: overt expression of persuasion

The low scores on D4 indicate that texts from all six disciplines lack overt expressions of persuasion. It appears that the results agree with Biber's (1988:194) assertion that social and natural sciences are 'non-persuasive.' Figure 4 indicates that conclusions from natural sciences and social sciences (-3.03 vs. $-.94$) display significant variation along this dimension ($t = -13.39, p < 0.001$), indicating that individual texts may vary across disciplines due to differences in personal style and purposes of communication. It has also been stated by Biber (1988) that education academic prose is quite persuasive compared to the other academic sub-genres, which explains the highest mean scores of education conclusions among six disciplines along D4.

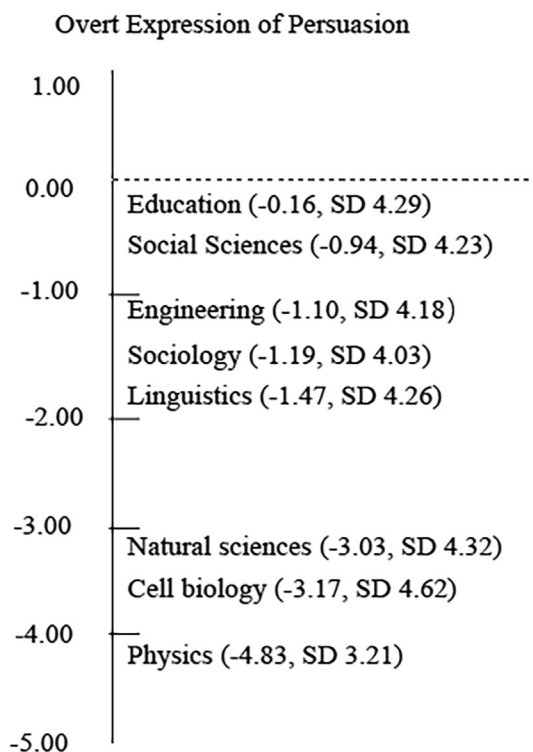


Figure 4. Dimension Scores along Dimension 4 for the Six Disciplines Analyzed in this Study.

Persuasion is expressed by using infinitives (*to*), suasive verbs, and modal verbs (Biber, 1988). Further, the results also suggest that conclusion writers in social sciences often use persuasion devices to convince the readers of the value of the study, as opposed to conclusion writers in natural sciences. In particular, social science conclusions have high mean scores in infinitives (0.53), suasive verbs (0.75), necessity modals (0.12), and possibility modals (0.91). An examination of the dimension scores of each discipline suggests that conclusion writers in education use more explicit persuasion than the writers of the other five disciplines, as shown in Figure 4.

The mean score of engineering conclusion texts is very close to sociology and linguistics along D4. It has been noted that engineering is less hard than physics and is more prone to the applied side, whereas 'sociology is a multiple paradigm science' involving applied knowledge (Becher & Trowler, 2001: 188). Besides, linguistics contains textual analysis that belongs to the harder area. The overlapping nature of these disciplines may help explain the similar mean score of engineering with sociology and linguistics along D4. Furthermore, Estaji and Vafaeimehr (2015: 49) found that writers from engineering tend to use linguistic features to convince their target readers that their findings are logical and true. This also conforms to the overall communicative purpose of the conclusion to persuade the audience that the value and application of the research findings in engineering are important. As shown in Example 13, the conclusion writer from engineering employs the **suasive verb 'propose'** to reiterate the research findings and **'allows'** to indicate the value of the research. Finally, the writer uses the **possibility modal 'can'** to emphasize the implications of the research findings. The construction demonstrates the conclusion writers' intention to persuade the target readers and promote the research findings.

- (13) This paper **proposes** a novel optimization tool for energy management within, small electric energy systems including vehicle-to-grid systems. A methodology to properly model vehicles aggregation is also presented. The optimization model, which materializes in a linear programming algorithm, **allows** assessing the effect of vehicle-to-grid as a contribution to the management of energy resources of a SEES. The proposed methodology is flexible, so that further developments **can** be easily foreseen...(ConLHS_2012EPSR_004, Engineering).

In social science domains, education conclusions (1.11) use more infinitives than sociology (0.34) and linguistics (0.13). In terms of the use of modals, conclusions in education are more likely to use prediction modals (**will**) than conclusions in other disciplines, either to present the overall findings (Example 12) or to point out future directions. Conclusion texts in education (0.17) and sociology (0.21) use comparatively more necessity modals (e.g., **should, must**) and possibility modals (e.g., **may**) to emphasize the further research directions (Example 14 and 15). This is consistent with the communicative purposes of indicating the future direction of research in the conclusion sub-genre.

- (14) However, like any new technology, student blog usage **will not** directly increase their learning without appropriate content, scaffolding, and strategies (Ellison & Wu, 2008)...One of the important issues for future research **would be** to investigate the long-term impacts of the blog use in teacher education courses. It **may** also be interesting to observe how students' attitudes, beliefs, and amount of usage change over time after being exposed to blogging. (ConLSS_2010IHE_003. Education).
- (15) The benefits of TTES for promoting enjoyment and personal connection to a topic that can often cause students anxiety **should be** explored with other controversial topics. (ConLSS_2013SCE_004. Sociology).

Generally speaking, conclusions in the six disciplines explored in this study have a relatively high frequency of using possibility modals (e.g., *might, may*), which are considered hedged remarks to emphasize the implications of the research. In Example 16, it can be seen that writers from the field of education frequently use possibility modals to try to avoid blunt assertions in their suggestions for applying the research findings. It can also be seen in biology that writers prefer using possibility modals to emphasize the implication of the research findings (Example 17).

- (16) Our study suggests that teachers **might be** mainly paradigmatic and superficial not only when solving standard problems, as in Depaepe's study, but also when solving nonstandard problems with relevant additional information. (ConLSS_2012TTE_0012. Education).
- (17) We show here that olfactory stem cells can be expanded in vitro. It should however be pointed out that the same technique **can be** used for cultivating other olfactory cell types of interest, especially the olfactory unsheathing cell. The latter **can be** easily amplified in culture... (ConLHS_2014SCR_0013. Biology).

3.5. Dimension 5: abstract and non-abstract information

Across all six disciplines, conclusion texts loaded positively on D5, illustrating highly abstract, technical, and formal language in these texts (Biber, 1988). The dimension scores for conclusion texts from natural and social sciences are 5.75 and 5.29, respectively. No significant differences between the two domains ($t = 2.33$, $p = 0.20$) were found, indicating that conclusions from both science fields are abstract.

In terms of the linguistic features along D5, conclusion texts from social sciences use more conjuncts (4.15 vs. 3.77), other adverbial subordination (0.73 vs. 0.36) and {predicative adjectives} (e.g., *ongoing, challenging*) (1.28 vs. 0.72) than natural sciences, indicating an evaluation of the findings (Example 18). In contrast, natural sciences use more **agentless passives** (0.88 vs. 0.16), past participial clauses (1.79 vs. 1.25), by-passives (1.06 vs. 0.31), **past participial WHIZ deletions** (0.75 vs. 0.26) than conclusions from social sciences. In Example 19, the writer used **agentless passives** and **past participial WHIZ deletions** to introduce the technique used in the study. This suggests that natural science conclusions are more procedure-oriented (Biber, 1988:112).

- (18) Conducting research **while this process of corrosion is [ongoing]** can be {challenging} and has the potential to further exacerbate stressors and tensions (Kroll-Smith and Couch, 1990). (ConLSS_2015SF_002.Sociology).
- (19) This unique technique **developed in rats** allows in less than 15 min to biopsy olfactory mucosa.....It should however **be pointed** out that the same technique can **be used** for cultivating other olfactory cell types of interest, especially the olfactory ensheathing cell. (ConLHS_2014SCR_0013. Biology).

However, an investigation of the dimension scores for the six disciplines along D5 demonstrates significant variation between engineering and education, with education having the lowest score, as shown in Figure 5. The co-occurrence of these features demonstrates complex logical relations (Biber, 1988). The prominent language features along the positive pole on D5 include conjuncts, agentless passives, and past participial clauses. Conclusions from six disciplines all have a high frequency of using conjuncts (e.g., *furthermore*). Besides, the results showed that engineering conclusion texts frequently use agentless passives, which indicates a focus on the research findings rather than the people who conducted the research. Among the six disciplines, conclusion texts from physics are most frequently characterized by the use of [by-passives] (1.8), which suggests the procedural-oriented nature of physics due to the description of the process of the research (Example 20) (Biber, 1988: 112) that describes how the research is carried out. It was also found that conclusions from biology had the highest score on using conjuncts (4.57).

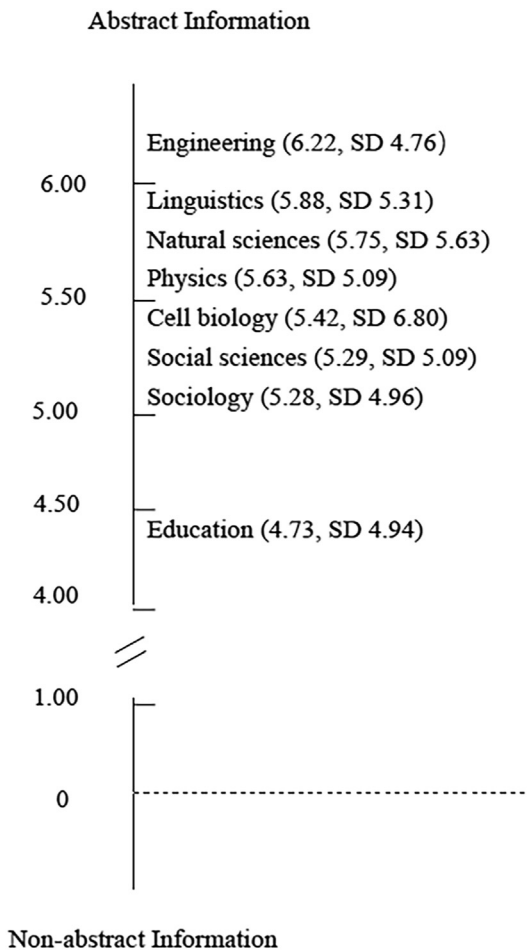


Figure 5. Dimension Scores along Dimension 5 for the Six Disciplines Analyzed in this Study.

In situ synthesis of TiO₂/HA/TCP composite coating [was realized by] using a novel laser-microwave hybridization method with combination of laser micropatterning, microwave heating and in situ synthesis. A microarchitecture with significant improved Ra roughness value of 8.7 μm [was obtained by] selective laser ablation and NaOH treatment. (ConLHS_2017SCT_0022. Physics).

4. Conclusion

4.1. Major findings

The results of the MD analysis of conclusion sections in social sciences and natural sciences demonstrate several substantive findings concerning the linguistic features and disciplinary variation in these sections. The MD analysis of conclusions from the natural and social sciences in this study is based on five out of Biber's (1988) seven dimensions (D1: Involved vs. Information Discourse; D2: Narrative vs. non-narrative Concerns; D3: Context-Independent vs. Context-Dependent Discourse; D4: Overt Expression of Persuasion; D5: Abstract vs. Non-Abstract Information) resulting from the use of a multi-dimensional analysis tagger (Nini, 2019). According to the dimension scores and the analysis of the conclusion texts, the following major findings can be drawn from this study.

Concerning the two research questions, the findings show that the conclusion sections written by professionals from the natural and social sciences differ significantly in three dimensions (D1, D2, D4). It has also been found that the linguistic features along different dimensions may be influenced by the communicative purpose of the conclusion sections. The results of the study also suggest that the dimension scores of the conclusion sections from the six disciplines (education, linguistics, sociology, engineering, physics, biology) conforms to the general distinction of social and natural sciences.

First, conclusions texts produced by natural science writers are more information condensed than those from social science writers, and conclusion texts from the social sciences displayed more linguistic features of involved discourse as indicated by the significantly higher D1 score. The interactive nature of social science conclusions is represented by using more emphatics (e.g., **more**, **most**), WH clauses, and possibility modals (e.g., **may**, **might**) than natural science conclusions. In

natural science conclusions, more nouns are used compared with social science conclusions, consistent with Biber and Gray's (2013) claim that natural science writing takes on a denser nominal style in comparison to social science disciplines. Within the soft knowledge domains, conclusion texts from education demonstrate more linguistic features used to express involvement than conclusion texts from sociology and linguistics. In particular, conclusion writers from education tend to use more WH clauses, private verbs, and possibility modals, which are linguistic features associated with involved discourse. The highly informative nature of conclusions can be attributed to the rhetorical function of presenting the overall findings in the conclusion sections. Besides, conclusion writers from the social sciences may use more positive features than writers from natural science and technologies to engage with readers and achieve the communicative purpose of promoting the overall findings.

Second, along D2, conclusions from the six disciplines all display a non-narrative feature, which conforms to the general academic convention. The non-narrative features help the conclusion writers convey the scientific findings. However, it was found that the social science conclusion corpus contains more elements of narrative features than the natural science conclusion corpus, as shown by the significantly higher D2 scores. The differences in the D2 score may be related to the frequent use of public verbs, and third-person pronouns (e.g., *they*, *their*) in the social science conclusion corpus, which focuses on narrating the research process. The disciplinary variation may also result from the human-centered way of researching in social sciences, which is often inquiry-based and "showing how human actions influence events" (Hyland, 1998, p.448). Specifically, conclusion texts from linguistics have higher D2 scores than those in other disciplines. The results are somehow reminiscent of the Human focus vs. Non-human focus (D3) of Gray (2015) where she pointed out that 'the discipline of applied linguistics is concerned with humans and language.' This helps explain some non-narrative elements in linguistics.

Finally, conclusion writers from the science and technology fields use significantly less explicit language features to present the overall findings of the research, as evidenced by the significantly lower D4 scores. Specifically, conclusions writers from social sciences tend to use more infinitives (e.g., *to*), necessity (e.g., *must*), and possibility modals (e.g., *may*, *might*) to explicitly convey their attitudes as well as their evaluation of the research findings than natural scientists. Thus, writers from social sciences can present knowledge as a common understanding and promote tolerance in readers' resulting in realizing the purpose of emphasizing the value of the study (Hyland, 2008). In general, natural science conclusion writers tend to minimize the role of the researcher when introducing the overall findings. The less explicit nature of conclusions from the hard knowledge field can be explained by the 'scientific ideology' of hard fields, which 'allows scientists to emphasize demonstrable generalizations rather than interpreting individuals' (Hyland, 2008:15). Moreover, within the social science field, conclusion texts from education and sociology make use of significantly more prediction modals (e.g., *will*) to point out the future direction of the research. Within the natural science domain, conclusion texts from biology and engineering display more explicit persuasion language. The main contribution to this feature is the use of possibility modals and suasive verbs. However, it should be pointed out that conclusion texts from the six disciplines are likely to use possibility modals (e.g., *could*, *can*) to introduce to the target reader the implications of the studies, which is another way to enforce the applicability of the research findings in the last section of the research article. This can leave an impression of the extra value of the research on the reader. The findings indicate that a high score in using possibility modals along D4 might be closely related to the communicative function of presenting the applicability of the findings in conclusions.

4.2. Implications, limitations, and future research

Overall, the findings of the current study add contributions to the pedagogical and practical implications of the EAP and ESP fields, which is an everlasting topic around the world of academia. The current research also highlights the importance of conclusion sections across different disciplines, adding to the growing knowledge about RA sections. Consequently, the investigation of conclusions in the present study complements earlier studies in exploring linguistic features of RA conclusions (e.g., Loi et al., 2016; Amnuai & Wannaruk, 2013; Sheldon, 2018).

Moreover, the findings of linguistic features concerning social sciences and natural sciences conclusions sections can inform ESP and EAP teachers as well as educators of how to teach discipline-specific conclusions in terms of the persuasion as well as promotion strategies employed. The tagged corpora of social and natural sciences can be used conveniently as teaching materials in academic writing courses to show students the language features that characterize RA conclusion sections. The corpora can also be used to extract examples for students to differentiate conclusions from different disciplines. Therefore, students and novice writers can improve their awareness of a particular genre.

The study offers insight into how conclusion writers from social sciences and natural sciences present their research findings differently, which sheds light on how conclusion writers communicate and present their findings and the value of the studies, as well as the potential directions for their future research. Besides, the current study also demonstrates the robustness of Biber's (1988) dimensions as well as the applicability of multi-dimensional analysis in terms of examining the microscopic aspects of discourse. Taken together, the findings of this study have not only implications on academic writing for novice writers but also have a pedagogical implication in EAP and ESP classroom settings.

However, the present study is not without limitations. Being limited to the number of disciplines, the results of this study may not be applicable to a wider variety of disciplines. Another issue that was not addressed in this study is whether the linguistic features of RA conclusions differ from those of other RA sections. Therefore, future research can further explore disciplinary variation in conclusions as well as in other RA sections and may conduct a comparative analysis of the linguistic

variation in different sections. The MD analysis can also be tailored to incorporate more linguistic features, such as the collocations proposed by [Cao and Xiao \(2013\)](#) with genre analysis of the conclusions. Besides, scholars can also conduct a new MD analysis using the conclusion corpus. At last, including more disciplines in the corpus may help researchers gain more insights into academic writing.

Data availability

Data will be made available on request.

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Appendix A. Journal List

Cell biology

Biosystems
Cellular and Molecular Life Sciences
Journal of Molecular and Cellular Cardiology
Stem Cell Research

Electrical Engineering

Electric Power Systems Research
Engineering Applications of Artificial Intelligence
Expert Systems with Applications
Journal of Electronic Packaging

Physics

Applied Surface Science
Current Applied Physics
Nano Energy
Surface & Coatings Technology

Education

Educational Research
International Journal of Educational Research
Internet and Higher Education
Learning and Instruction
Research in Higher Education
Science Education
Teaching and Teacher Education

Linguistics

Applied Linguistics
Brain and Language
Journal of Second Language Writing
Systems

Sociology

Annals of Tourism Research
International Journal of Intercultural Relations
Race and Social Problems
Rural Sociology
Social Indicator Research
Social Networks
Social Science Research
Sociological Forum

Appendix B. One-way ANOVA for six disciplines along five dimensions

Dimensions		Sum of Squares	df	Mean Square	F	Sig.
Dimension1	Between Groups	20004.537	5	4000.907	98	0
	Within Groups	122701.731	2994	40.983		
	Total	142706.268	2999			
Dimension2	Between Groups	502.951	5	100.59	13	0
	Within Groups	22650.145	2994	7.565		
	Total	23153.096	2999			
Dimension3	Between Groups	1874.226	5	374.845	18	0
	Within Groups	63255.824	2994	21.128		
	Total	65130.049	2999			
Dimension4	Between Groups	7245.236	5	1449.047	85	0
	Within Groups	50876.179	2994	16.993		
	Total	58121.415	2999			
Dimension5	Between Groups	658.901	5	131.78	4.6	0
	Within Groups	85844.618	2994	28.672		
	Total	86503.519	2999			

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