Linking adverbials in research articles across eight disciplines

Matthew Peacock

City University of Hong Kong (China)

enmatt@cityu.edu.hk

Abstract

Biber et al. (1999) contend linking adverbials perform important cohesive and connective functions by signalling connections between units of discourse; however, there has been little previous corpus-based research in this important area of ESP. This paper describes an analysis of linking adverbials, such as "however" and "therefore", in a corpus of 320 published research articles (RAs) across eight disciplines, four science and four non-science. New lists of linking adverbials were developed and the parameters of frequency, function and disciplinary variation were examined using WordSmith Tools. They were found to be more frequent than previously thought, with numerous statistically significant disciplinary differences, for example between the sciences and non-sciences. Also, they often clustered together in complex sequences. A close examination of RAs in two of the sciences revealed some reasons for the much lower rate of occurrence there. Authors developed claims in a different way, describing methods and results in a more narrative or descriptive style rather than explicitly telling readers the connections between ideas, claims and facts. Conclusions are that linking adverbials are more important in RAs as signalling and cohesive devices, and for helping RA authors construct and strengthen claims, than previously thought by experts in this field. Also, different disciplines achieve this in significantly different ways, confirming the importance of discipline variation when researching their use.

Keywords: English for Specific Purposes, linking adverbials, corpus analysis, interdisciplinary research writing, genre analysis.

Resumen

El uso de adverbios conectores en artículos académicos de ocho disciplinas diferentes

Biber et al. (1999) afirman que los adverbios conectores realizan importantes

funciones cohesivas y conectivas señalando conexiones entre unidades del discurso; sin embargo, no existe mucha investigación basada en análisis de corpus en esta importante área de Inglés para Fines Específicos. En este artículo se analiza el uso de adverbios conectores, por ejemplo *however* y *therefore*, en un corpus de 320 publicaciones académicas de ocho disciplinas diferentes, cuatro de ciencias y cuatro no de ciencias. Se elaboraron nuevas listas de adverbios conectores y se examinaron su frecuencia, función y variación según las disciplinas utilizando WordSmith Tools. Se descubrió que su frecuencia era mayor de lo que se creía, produciéndose importantes diferencias entre disciplinas desde el punto de vista estadístico; por ejemplo, entre las ciencias y las no ciencias. Además los adverbios conectores aparecían juntos a menudo formando secuencias complejas. Un análisis más minucioso de los artículos de investigación en dos de las disciplinas científicas reveló algunas razones que justifican su menor frecuencia en dichos campos. Los autores desarrollaban su argumentación de forma diferente, describiendo los métodos y los resultados en un estilo más narrativo o descriptivo en vez de alertar explícitamente a sus lectores de las conexiones entre ideas, afirmaciones y hechos. Se concluye en este estudio que la importancia de los adverbios conectores en los artículos de investigación reside en su función como instrumento señalizador y de cohesión, así como en ayudar a sus autores a construir y a fortalecer su argumentación; y que dicha importancia parece mayor de lo que se pensaba. Además, en diferentes disciplinas esto se consigue de formas claramente diferentes, confirmándose así la importancia de la variación disciplinaria a la hora de investigar el uso de estas expresiones.

Palabras clave: Inglés para fines específicos, adverbios conectores, análisis de corpus, artículos de investigación en diferentes disciplinas, análisis de género del discurso.

1. Introduction

This paper describes a corpus-based analysis of linking adverbials such as "however" and "thus" in research articles (RAs) across eight disciplines –Chemistry, Computer Science, Materials Science, Neuroscience, Economics, Language and Linguistics, Management, and Psychology. The purpose of the research was to study interdisciplinary differences in the frequency, form and function of the linking adverbials that authors use. There seems to be little research in the area since Biber et al. (1999), apart from Biber (2006).

In this article Conrad's (1999: 3) definition of linking adverbials is used:

"those adverbials that serve to connect two stretches of discourse". Biber et al. (1999: 765, 875) add to this definition, saying they "make explicit the relationship between two units of discourse". They signal these relationships and are therefore "important devices for creating textual cohesion". The following extract from a Neuroscience research article in the corpus shows an example:

> The criterion measure, B, was positively skewed and *thus* log transformed values were used for all analyses.

Thus here signals a logical connection – the author used log transformed values because measure B was positively skewed. In other words, the second unit is a consequence of the first.

The RA was chosen for this study because of its importance for spreading knowledge. Hyland (1996) says RAs are a vital medium for legitimating findings and disciplines, and Williams (1998) calls them the preferred genre for communication among discourse communities, noting that the language of RAs defines these communities. Pressure to publish makes RAs very important for researchers, and therefore it is not at all surprising that authors wish to stress the importance of their work and persuade readers of the authenticity of their arguments and claims. Moreno (1997) calls this their primary aim. However, Hunston (1994) suggests that while some may see RAs as objective and impersonal, their real aim is to persuade. Hyland (2000) agrees, saying the main purpose of the RA is to persuade, convince peers, and establish credibility.

The corpus was 320 published research articles, forty from each discipline. The research aim and approach was not only to explore these cohesive and connective functions, but to investigate how these adverbials may assist in the performance of other important functions in RAs – presenting, developing, and supporting claims; together with persuading, convincing peers, and establishing credibility.

The disciplines were classified for this research as science or non-science. The following methods were used to achieve this. First, visits were made to the academic departments representing the disciplines, and experts asked to discuss the classification. There was little controversy regarding Chemistry, Computer Science, Materials Science, and Neuroscience (sciences), or Management and Language and Linguistics (non-sciences). Regarding Economics, however, experts noted that while they consider it a non-science, it is sometimes called a

social science, and found in university Faculties of Humanities/Social Sciences. There was a little more controversy with Psychology. Sources said that while this topic has initiated some discussion, neither they nor their colleagues classify it as a science, adding that among the 15 or so branches of psychology, just one branch is considered a science: Clinical Psychology. Second, it is noted that university Psychology departments are not normally found in Faculties of Science. Therefore the decision was made to classify Psychology as a non-science for the present research.

2. Definition and functions of linking adverbials

Conrad's (1999) and Biber et al's (1999) definitions of linking adverbials appear in the previous section. However, the terminology, definition, and functions of linking adverbials have occasioned further discussion in the literature, with other authors sometimes using varied terminology. Carter and McCarthy (2006) call them "linking adjuncts" and distinguish them from the closely related conjunction. Conjunctions like "because", "neither", "nor", and "but" also link two clauses or other units, but differ from linking adverbials in that they have a "purely syntactic role" (Biber et al., 1999: 85). Biber et al. (1999) also discuss coordinating conjunctions, which they also call coordinators, and subordinating conjunctions such as "despite" and "in spite of", which they also call subordinators, noting that they are closely related to but different from linking adverbials. The authors further note that "though", "so" and "yet" can function either as linking adverbials or as conjunctions – "though" as a subordinator, "so" and "yet" as coordinators. Their study provides an example of "though" functioning as a subordinator, "She had never heard of him, *though* she did not say so". An example of "so" as a conjunction is "I rose early *so* that I'd get there on time". The following extract from the corpus for this study shows an example of "so" functioning as a linking adverbial: "There are lots of different levels and angles of interest. *So* the decisions are slow and complicated" (Management).[1]

Biber et al. (1999) indicate adverbials fall into three different classes: (a) circumstance adverbials (e.g. "nowadays"), which add circumstantial information about propositions in clauses, (b) stance adverbials (e.g. "definitely"), which express stance towards clauses,[2] and (c) linking adverbials, which serve a connective function, making the relationship between two units of discourse clear, and are important cohesive devices.

The authors further divide linking adverbials into six "semantic categories", which express the following different relationships:

1. Enumeration (e.g. "first", "second") and addition (e.g. "also"). The latter mark the next unit of discourse as being additional.

2. Summation, such as "to conclude".

3. Apposition, which show the following text is an example (e.g. "for example") or reformulation (e.g. "that is").

4. Result/inference (e.g. "therefore"), which show the following unit is a result, or a logical or practical consequence. It also marks the conclusions the reader is expected to draw, or connects claims to supporting facts.

5. Contrast/concession (e.g. "*however*"), which indicate alternatives. They add that some highlight contrasting information, often leading to the main point the writer wants to make, and others express reservations "about the idea in the preceding clause".

6. Transition, for example "by the way", which mean something is only loosely connected.

3. Previous empirical studies

Few empirical studies seem to have used corpora to research linking adverbials: three important studies are Biber et al. (1999), Biber (2006) and Charles (2007). Biber et al. (1999) examined four registers in the Longman Spoken and Written English (LSWE) corpus: news articles, academic prose (book extracts plus RAs, 2.6 million words each), fiction and conversation. Academic prose was 5.3 million words. There were seventy-five book extracts, mostly technical trade books, from thirteen different disciplines, and RAs from fifteen different disciplines. Linking adverbials were much more common in academic prose and conversation than in fiction and news.

Biber et al.'s (1999) estimations show that in academic prose the result/inference category was the most common, since in this type of text presenting and supporting claims is very important, and, as these are developed, there is a greater use of linking adverbials. Regarding stylistic preferences, their work demonstrates that choices for the result adverbials "therefore", "thus" and "hence" show more variability by author, and that

these three adverbials seem to be interchangeable. It is also noted that multiple adverbials can appear in a clause (e.g. "going *slowly now*"), and that a single sentence may contain more than one linking adverbial (e.g. "in addition" plus "however").

Biber (2006) presents corpus results for five individual linking adverbials in textbooks across five disciplines (760,600 words), in "institutional writing" (catalogues and student handbooks, 151,500 words), and in "written course management" (course packs and course management, 159,600 words). He reports linking adverbials to be less common in "written course management", and still less common in "institutional writing".

Charles (2007) presents corpus results for eight individual linking adverbials in eight first language (L1) Politics M.Phil. theses (190,000 words), and eight L1 Materials Science doctoral theses (300,000 words). The author's bar chart does not provide exact numbers, as in the case of Biber et al. (1999), but their estimated figures are approximately as indicated in Table 1, which shows the results from all three empirical studies.

These three studies, referred to above, and particularly Biber et al. (1999), are by far the most important to date in this area of ESP; although Conrad, in a later paper repeating many of Biber et al.'s (1999) (see Conrad 2000), calls for much more research into linking adverbials, particularly regarding register variation.

Semantic Category	Biber et al 1999: LSWE academic prose — Whole Semantic Category	Individual Linking Adverbials	Biber et al 1999 — LSWE academic prose	Biber 2006					Charles 2007	
				Business Textbooks	Engineering Textbooks	Humanities Textbooks	Natural Science Textbooks	Social Science Textbooks	Politics M. Phil. Theses	Materials Science Ph.D. Theses
Contrast/ concession	1200	however	1100	1400	1100	800	1000	1000	1700	1900
		nevertheless	100	-	-	-	-	-	-	-
		yet	100	-	-	-	-	-	300	50
Result/ inference	3000	thus/therefore	1300	1300	1800	900	1300	1100	1700	1700
		hence	100	-	-	-	-	-	200	500
Addition	1000	furthermore	100	-	-	-	-	-	250	150
		in addition	-	-	-	-	-	-	100	300
Apposition	1800	for example	600	1400	1400	700	1000	1000	500	300
		e.g.	200	-	-	-	-	-	-	-
		that is	-	400	900	200	300	300	-	-
		i.e.	200	-	-	-	-	-	-	-

Table 1. Previoius empirical findings: Frequency per million words.

4. Rationale for research

As noted in the previous section, Biber et al. (1999) contend that presenting, supporting and developing claims, and textual cohesion, are very important in academic prose. Shaw (2000) also says it is important in RAs to develop arguments, and support claims. Shaw (2000) and Hunston (2001) both also point out that research writers organize arguments into long chains (also see Hoey, 2001), but neither author discusses how they do this. It is suggested that these authors are correct about the importance of supporting and developing claims in RAs, and that linking adverbials might play a role in helping authors to achieve this. Yet data on linking adverbials, across disciplines and particularly in the sciences, seems to be lacking. Liu (2008) calls for "more detailed" corpus-based research on linking adverbials, noting that this method is the only way to achieve accurate and reliable results. It is proposed that the area has not received the attention it warrants and that further research is needed, to assess disciplinary variation across a number of science and non-science disciplines.

This research focuses on four of Biber et al.'s (1999) semantic categories for linking adverbials: "contrast/concession", "result/inference", "apposition", and "addition". The first three were chosen because the functions they perform appear to be an important part of presenting, supporting and developing claims. "Addition" was selected because preliminary examination of the corpus indicated that linking adverbials such as "also", which Biber et al. say function to show the next unit is additional, in fact often aid writers to introduce claims. In order to make this research more manageable, other categories analysed by Biber et al. (1999) were left aside, because they may be less important in developing claims and are regarded as beyond the scope of the present study.

Bhatia (2000) says a strong justification for genre research in ESP is that it informs the teaching of research writing, especially for writers who wish to join academic discourse communities. The area is increasingly important due to the fast-growing numbers of research writers around the world, and is worth further investigation. The results might tell us much more about ESP and the nature of RAs, and help teachers of research writing inform learners of appropriate patterns.

Although there is a considerable amount of information about the RA available, much still remains to be discovered about this subject; and a number of authors have called for more research. Swales (2004) does not

contradict his previous claim that our picture of the RA "is far from complete" (Swales, 1990). Berkenkotter and Huckin (1995) note that understanding genres is vital for participation in relevant discourse communities. Hyland (1996 & 1997) says a better understanding of RAs will improve understanding of rhetoric and how scientists work. This will also help the teaching of ESP. Writing theses and RAs is difficult (Paltridge, 1993), and is a prerequisite for entry to the research community. Hopkins and Dudley-Evans (1988) suggest that ESP materials must be informed by genre research and that understanding disciplinary differences is essential for preparing ESP courses.

The next section will explain the aims of this research and also describe the corpus, how the list of linking adverbials was built up, and how the corpus was searched.

5. Methodology

The aims of this study were to advance and extend previous research on the form, frequency, function and distribution of linking adverbials in RAs across eight disciplines, four science (Chemistry, Computer Science, Materials Science, Neuroscience) and four non-science (Economics, Language and Linguistics, Management, and Psychology), and to develop a more comprehensive list of linking adverbials.

5.1. Research aims and research questions

The aims of this research were, within the corpus, to:

    (1) build up a list of linking adverbials in the four target categories;

    (2) investigate the frequency of all linking adverbials in the target categories;

    (3) investigate disciplinary variation;

    (4) investigate function.

The following questions are directly addressed:

    (1) How frequently do RA authors use linking adverbials across a range of disciplines? Are there any interdisciplinary differences?

    (2) What linking adverbials do RA authors use across a range of

disciplines? Are there any interdisciplinary differences?

(3) How do linking adverbials function across a range of disciplines? Are there any interdisciplinary differences?

5.2. The RA corpus

The corpus was 320 published RAs, forty from each discipline. Table 2 shows the length of disciplinary corpora.

DISCIPLINE		Number of RAs	Total Word Length
Science	Chemistry	40	137,241
	Computer Science	40	286,171
	Materials Science	40	160,222
	Neuroscience	40	243,057
Non-science	Economics	40	292,488
	Language and Linguistics	40	249,854
	Management	40	285,825
	Psychology	40	306,184
	FOUR NON-SCIENCES	160	1,134,351
	FOUR SCIENCES	160	826,691
	ALL DISCIPLINES	320	1,961,042

Table 2. Lengths of disciplinary corpora.

The eight disciplines were selected because they represent a range of subjects and also have large numbers of research writers around the world. This increases the usefulness of this research regarding recommendations for teaching ESP. Four leading refereed journals were selected from each discipline (see Appendix). The academic departments representing the eight disciplines were visited, and two sources from each were asked to name principal journals from their field.

Ten RAs from 2007/2008 were randomly chosen from each journal by giving each a number and drawing numbers from a box. Only empirical data-driven RAs with the Introduction-Method-Results-Discussion format were chosen. Essays and discussions were excluded, and only one RA by any one writer was included in the corpus – that is, no writer's name appears twice. No attempt was made to choose native-speaker authors, which in any case cannot be identified by merely looking at their name or the name of the institution where they work. It is suggested that the disciplinary corpora are sufficiently representative because of their size and because of the use of discipline sources to choose journals.

5.3. Investigating the corpus

Analysis was done in the following steps, using the Concord and Contexts functions of WordSmith Tools 4.0 (Scott, 2004). Explanation of certain steps follows:

STEP 1. A list of 46 linking adverbials was constructed from Biber et al. 1999, other grammars, and a thesaurus. This is more extensive than previously published lists.

STEP 2. A preliminary examination of the corpus was conducted to check the function of all 46 linking adverbials, to see whether they do in fact always function as linking adverbials or not. This was done by individually checking a large number of occurrences of each in each discipline corpus and evaluating function by reading the relevant sentence and surrounding sentences. At this stage it was found that eight, in addition to the dual-function items "though" and "so" discussed in the introduction, do not always function as linking adverbials:

i.   "rather" (exclude e.g. "rather quiet", "rather tired")

ii. "yet" (exclude e.g. "we have not eaten yet", "it is not yet clear")

iii. "alternatively" (exclude e.g. "content and language were alternatively the central focus")

iv. "similarly" (functions as a linking adverbial only in a sentence initial position. An example as non-sentence initial is "men and women behave similarly")

v.   "further" (functions as a linking adverbial only when followed by a comma)

vi. "in the same way" (functions only in a sentence initial position. An example as a non-sentence initial is "children respond in the same way")

vii. "that is" (functions as a linking adverbial only when followed by a comma)

viii. "specifically" (functions only in a sentence initial position. An example as non-sentence initial is "the present study set out to specifically investigate").

STEP 3. The frequency of all linking adverbials was checked, along with disciplinary variation. All cases of "though" and "so" plus the above eight items not functioning as such were naturally excluded from the

count: this required manual examination of every occurrence of each using the Concord function. Conjunctions (e.g. "although", "while", and "whereas") were also excluded, because they are not linking adverbials (Biber et al., 1999; Carter & McCarthy, 2006).

STEP 4. The function of every occurrence of all linking adverbials was individually checked by reading the relevant sentence and surrounding sentences.

STEP 5. The frequency of all linking adverbials was examined within individual journals, to check if any were used significantly more frequently by certain journals.

STEP 6. Statistical significance was set at $p<.05$ and tested with the chi-squared test within the log-likelihood calculator.

Regarding steps 2 and 3, the corpus was split into disciplinary corpora at times to check disciplinary variation. Regarding steps 2, 3, and 4, "function" means "operates" or "acts". Individual manual checking of the function of every occurrence is vital[3].

Two evaluators were involved in step (4): this writer and a local university lecturer. The second coder independently evaluated the function of every occurrence in order to measure inter-rater agreement. This writer reassessed the function of every occurrence after one month in order to measure intra-rater agreement. Inter-rater agreement was 97%, rising to 100% after discussions. Intra-rater agreement was 99%.

6. Results

This section will start with the results for the three research questions. A total of 23,544 functioning linking adverbials were found in the whole corpus. The frequency of use was 12,006 per million words, or 74 per RA, though the number was drastically lower in Chemistry (24 per RA) and much lower in Materials Science (36 per RA). The number per RA for the other disciplines was Economics 89, Language and Linguistics 84, Management 97, Psychology 107, Computer Science 84, and Neuroscience 68. The authors of all 320 RAs used them. Frequency across all four semantic categories, and disciplinary differences, are shown in Tables 3, 4, 5, and 6 per million words (pmw). The forms are all in frequency order, with the most common first. Table 3 does not show all the contrast/concession forms, only those with a frequency of 100 pmw or above.

ITEM	All 4 non-sciences	ECON.	LANG.	MANAG.	PSYCH.
however	1380*	1401	1416	1308	1399
rather	456*	291*	560*	545	444
though	220*	164	256	217	248
in contrast/by contrast	205	182	176	133*	317*
instead	184	202	160	150	219
on the other hand	174*	202	168	136	186
nevertheless/nonetheless/notwithstanding	164*	96*	228*	119	219*
otherwise	122*	295*	56*	80	49*
TOTAL	3172*	3027	3292	2941*	3428*

ITEM	All 4 sciences	CHEM.	COMPU.	MATS.	NEURO.
however	1110	905*	979	1219	1313*
rather	305	161*	427*	138*	354
though	139	80	171	144	132
in contrast/by contrast	219	109*	140*	231	366*
instead	170	212*	192	69*	189
on the other hand	111	175	112	144	53*
nevertheless/nonetheless/notwithstanding	76	7*	91	44	119
otherwise	64	51	112*	25*	41
TOTAL	2426	1832*	2434	2206	2905*

* = statistically significant difference

Table 3. Contrast/concession linking adverbials: Discipline differences. Frequency pmw.

ITEM	All 4 non-sciences	ECON.	LANG.	MANAG.	PSYCH.
thus	914*	839	796	675*	1304*
therefore	696*	801	488*	930*	546*
so	412	469	568*	381	258*
hence	292*	586*	116*	294	154*
as a result	108	127	112	108	85
consequently	101*	82	88	143	92
thereby	72*	86	52	105	46
accordingly	71*	65	20*	84	105
for this reason	17	17	36	14	3*
TOTAL	2682*	2921*	2204*	2545	2441*

ITEM	All 4 sciences	CHEM.	COMPU.	MATS.	NEURO.
thus	644	489*	643	488*	840*
therefore	613	533	612	569	691
so	403	358	174*	46*	64*
hence	169	131	234*	219	82*
consequently	69	117	73	75	33*
thereby	41	29	45	44	41
accordingly	37	7*	49	38	41
for this reason	16	15	28	19	0*
as a result	117	80	154	200*	41*
TOTAL	2110	1723*	2353*	1856*	1951

* = statistically significant difference

Table 4. Result/inference linking adverbials: Discipline differences. Frequency pmw.

ITEM	All 4 non-sciences	ECON.	LANG.	MANAG.	PSYCH.
also	2196*	1908*	2588*	2385	1974*
as well	474*	291*	632*	605*	399
in addition	387*	387	392	353	415
moreover	196	315*	72*	175	203
furthermore	183	178	112*	231	199
Similarly	134*	92	140	161	144
further,	64*	51	72	84	52
additionally	59	45	60	59	72
likewise	37	21	48	28	52
besides	26	14	8	56*	26
In the same way	2	0	0	3	3
TOTAL	3758*	3301*	4124*	4140*	3539

ITEM	All 4 sciences	CHEM.	COMPU.	MATS.	NEURO.
also	1846	1263*	2105*	1856	1872
as well	368	299	448	338	333
in addition	326	197*	378	281	370
moreover	160	36*	150	231	193
furthermore	179	146	189	100*	239
Similarly	81	44	108	75	74
further,	40	22	70	13	33
additionally	53	66	42	69	49
likewise	30	58	31	19	21
besides	27	7	21	56	25
In the same way	5	15	0	0	8
TOTAL	3115	2153*	3542*	3038	3218

* = statistically significant difference

Table 5. Addition linking adverbials: Discipline differences. Frequency pmw.

ITEM	All 4 non-sciences	ECON.	LANG.	MANAG.	PSYCH.
e.g.	905*	473*	700*	706*	1670*
for example/for instance	862*	795	952	934	784
such as	840*	507*	1152*	1276*	493*
i.e./that is,	780*	736	688	448*	1209*
in other words	136*	75*	188	133	154
Specifically	84*	96	20*	112	98
namely	68	62	100	73	42
TOTAL	3674*	2743*	3800	3682	4451*

ITEM	All 4 sciences	CHEM.	COMPU.	MATS.	NEURO.
e.g.	711	88	863*	300*	1156*
for example/for instance	504	175	899*	194*	432*
such as	661	628	874*	625	457*
i.e./that is,	561	285*	573	519	733*
in other words	54	22	98*	13*	49
Specifically	52	15	52	50	74
namely	57	80	31	63	70
TOTAL	2601	1292*	3392*	1763*	2971*

* = statistically significant difference

Table 6. Apposition linking adverbials: Discipline differences. Frequency pmw.

6.1. Frequency – semantic categories

Three categories, contrast/concession, addition, and apposition, were found to be more common than previously thought. Frequency per million words over all eight disciplines was contrast/concession 2857, result/inference 2441, addition 3487, and apposition 3221 whereas Biber et al. (1999) report 1200, 3000, 1000, and 1800 respectively – though of course their corpus was 50% book extracts and 50% RAs. These four tables reveal some striking interdisciplinary variations in linking adverbial frequency. The first clear difference is that the sciences use significantly fewer linking adverbials than the non-sciences in all four semantic categories. However, this science/non-science difference varied by discipline: Chemistry used all four types significantly less often. Materials Science used two types significantly less often – result/inference and apposition. Computer Science used three types significantly more often than the other sciences – result/inference, addition, and apposition; Neuroscience used contrast/concession and apposition significantly more often. Other variations may be seen among the non-science disciplines.

6.2. Frequency – individual forms

The tables show the most common forms in each category. The first five in contrast/concession were "however", "rather", "though", "in contrast/by contrast", and "instead". The most common in the other three categories were as follows: result/inference "thus", "therefore", "so", and "hence"; addition, "also", "as well" and "in addition"; apposition "e.g.", "for example/for instance" and "such as". No significant difference in the frequency of use of any linking adverbial was found within any one journal.

Regarding contrast/concession, Table 3 shows a number of significant individual discipline differences in the use of individual forms. It also shows that the sciences used a narrower range of forms than did non-science authors: almost all forms in the table were used significantly less frequently by the sciences, except for the middle two, "in contrast/by contrast" and "instead". Science authors favoured these two forms. Regarding apposition (Table 6), after careful examination of two pairs of forms across the entire corpus, "for example/for instance" and "i.e./that is", it is concluded that they are interchangeable.

6.3. Function

Linking adverbials functioned only partly as predicted by Biber et al. (1999). Results from the four categories will now be presented, with numbered representative examples from the corpus:

6.3.1. Contrast/concession

Biber et al. (1999) say they indicate alternatives. While this was found to be sometimes true in this corpus of RAs, they are also sometimes associated with making claims, and it is suggested that the latter function may be more important in RAs. First, here is an example denoting alternatives:

> (1) David could have used the touch handshape to represent grasping objects <1 in. in diameter and the small handshape to represent grasping objects between 1 and 2 in. in diameter. *However*, he did not use the forms in this way (Psychology).

Second, here are two examples where the linking adverbial is associated with making claims. Example (3) uses two contrast/concession forms in one sentence. The second form marks the claim:

> (2) The drivers of value, which can be thought from the perspective of how a buyer actually evaluates a purchase situation, has been explicated to some degree in the purchasing management literature (…) *However*, what is missing is the interaction of the dyad and the preconditions (Management).

> (3) While the chronotopic approach is not intended to be used as a stand alone heuristic, but *instead* is intended to be used in conjunction with other teaching approaches, it is, *nevertheless*, an important step in coming to better understand what effects semantic and syntactic choices produce (Language and Linguistics).

6.3.2. Result/inference

It is suggested that Biber et al.'s (1999) assertion that these linking adverbials mark results or consequences is correct. An example follows:

> (4) The criterion measure, B, was positively skewed and *thus* log transformed values were used for all analyses (Neuroscience).

6.3.3. Addition

Biber et al. (1999) say that these show that the next unit is additional. While this was found to be often true in the corpus, it was noted that the very common form "also" often appears in chains. Additionally, "also" was often associated with making claims, and the latter function is assessed as being very important. First, here is an example showing the following unit is additional:

(5) *Also*, while the value of the diversity of GCAE members is recognised, the difficulty of having a wide range of linguistic competence is also acknowledged (Language and Linguistics).

Second, here are two examples of "also/as well" associated with claims. The forms also function to show that the next unit is additional, but it is suggested that to these authors, the "claim" function is particularly important. Example (7) contains three claims in one sentence:

(6) *Thus*, we expect that the two theories would *also* be useful to predict the acceptance of SDA (Computer Science).

(7) *As well* as providing a visual representation of each of the case companies, the framework also provides the means of comparing one cybermediary with another. The framework *also* offers a way of comparing any changes to the roles and relationships of a cybermediary over time (Management).

6.3.4. Apposition

It is proposed that Biber et al.'s (1999) contention that these forms show the following text is an example or reformulation is correct. However, regarding the first of these functions – showing that the following text is an example – linking adverbials in this category had the additional function of helping authors to make claims. This can be seen in example (8). Example (9) shows "reformulation":

(8) The SV-mix approach *also* provides a useful tool for investigating the implications of some interesting hypothetical scenarios. *For example*, suppose that one wishes to think about the implications of a peso-type situation involving a low-probability, high-impact event (Economics).

(9) An alternative explanation for our finding differences by behavior type may be that our stimulus behaviors differed in potency. *In other words*, perhaps our targets' smiles were quite distinct (Psychology).

Linking adverbials were found to be sometimes clustered together in long and complex sequences. These appear to be an important method of aiding in the strengthening of claims in RAs. Examples (3), (5), (6), (7) and (8) show this tendency. Another example follows:

> (10) *Rather* than thinking in terms of company promotions directly to consumers, *for example*, the team conceived joint advertising and promotions processes with the retailers, *such as* jointly sponsored mailings to retailer loyalty card holders. The team *also* realized that it had no product review procedure (Management).

7. Discussion and conclusions

Linking adverbials were found to be more common than previously thought, though the corpora were of course not identical. Table 7 compares the present results with Biber et al. (1999):

Semantic Category	Biber et al. 1999 – LSWE academic prose		Present Study			
	Frequency per million words	Percentage of Total	Frequency per million words		Percentage of Total	
			Non-science	Science	Non-science	Science
Contrast/ concession	1200	17	3172	2426	24	24
Result/ inference	3000	43	2682	2110	20	21
Addition	1000	14	3758	3115	28	30
Apposition	1800	26	3674	2601	28	25
TOTAL	7000	100	15055	11935	100	100

Table 7. Comparison of findings on four semantic categories: Biber et al. (1999) and present study.

Table 7 shows that in this study three categories (contrast/concession, addition and apposition) were much more common in RAs than in Biber et al.'s (1999) academic prose corpus (book extracts plus RAs). Result/inference was less common. These differences are striking. Another conspicuous difference is the proportion of three out of four semantic categories as a percentage of the whole. Contrast/concession made up around 24%, result/inference 20%, addition 29%, and apposition 25-28% (in this respect, the science and non-science disciplines were remarkably

similar) whereas Biber et al. (1999) report 17%, 43%, 14%, and 26% respectively.

One cause of these category results is that the present search covered a greater number of linking adverbials than Biber et al. (1999), who do not list very many individual forms. An example of this can be seen in Table 1. Biber et al. (1999) report the frequency of the contrast/concession form "however" as 1100 pmw, and the whole contrast/concession category as 1200 pmw: "however" makes up 92%. Yet in this study, the frequency of "however" over all eight disciplines was 1266 pmw, making up only 44% of the whole category. On top of this the frequency results for other individual forms were not much different from those reported in Table 1, yet the category frequencies are higher. Another important factor probably associated with the present results is the somewhat different corpora – Biber et al. (1999) used academic prose, book extracts plus RAs, around 50% each, and this factor must not be overlooked.

Turning to the meaning of the present results, they indicate that contrast/concession, addition, and apposition linking adverbials are more common and therefore more important in RAs than previously thought, if readers of Biber et al. (1999) assumed that their results applied to RAs. And the higher frequency of the contrast/concession category makes it appear particularly important. It contains a large number of linguistic forms (see Table 3) available to and used by authors, and the functions that are reported here, such as assisting authors to construct claims, make it perhaps very valuable for them. The same is also true for addition and apposition linking adverbials, considering their higher frequency and extra functions. And regarding the function of linking adverbials across all four categories, it is suggested that this study adds to Biber et al.'s (1999) descriptions. Biber et al. (1999) said in their broad description that linking adverbials signal relationships between two units of discourse and create textual cohesion (they only mention presenting and supporting claims in connection with the result/inference category), and in their more detailed description that they indicate alternatives; show results and consequences; or show the next unit is additional, an example, or a reformulation. All this is true but it is argued here that in the RA contrast/concession forms are also sometimes used to help authors make claims; addition forms often assist in introducing claims; and apposition forms help writers strengthen claims. Additionally, linking adverbials were found to be sometimes clustered together in long and complex sequences, which appear to be another important method of

supporting claims in RAs. It was noted in the introduction that it is very important for RA authors to persuade readers of the authenticity and validity of their claims, convince peers, and establish credibility, and therefore it is proposed that aiding writers with these functions is an important task.

Regarding individual disciplines, the sciences use significantly fewer linking adverbials than the non-sciences in all four categories. But a closer look at the results shows that this varied sharply by discipline, and that the major difference was in two of the four sciences – Chemistry and Materials Science. A much closer examination of Chemistry and Materials Science RAs was then undertaken to try to understand some of the reasons for this much lower rate of occurrence. It was observed that authors tended to present and to develop claims in a different way – they used less argument. They described their research justifications, methods, results and conclusions in a much more narrative and descriptive style: they seemed merely to describe the steps they took, and their findings, one by one, and let readers work out their claims. Presumably the aim is to show the order of events or rather, this order is sufficient for readers, who perhaps do not need to be explicitly told the connections between facts, arguments, and claims. These authors did less restating, reformulating, exemplification, and less linking units of discourse together. Computer Science and Neuroscience RAs, on the other hand, resembled the non-science disciplines much more. Some typical and representative examples of these factors from Chemistry and Materials Science from the corpus will now be shown. The first is from a typical Chemistry "justify our research" section:

> (11) All current materials of this type use simple inorganic fluorides such as NaYF4 as host structures for luminescent lanthanide cations (…) With this in mind, we have recently initiated an exploratory study of Group III element fluoride hydrothermal chemistry, using organic amines as structure-directing agents, in order to open up a new area of structural solid-state chemistry.

The next example is from a typical Chemistry conclusion section:

> (12) Here, it has been shown that MF-ICA is capable of providing good estimates of the elution patterns containing background, mass spectral sources and the area of the eight analytes in four clusters despite their heavily overlapped signals. The reasonable results would be obtained by selecting the proper parameters, such as number of sources, non-negative mixing prior and source prior values.

The next example is from a typical Materials Science "introduce our research" section:

(13) Spraycasting followed by hot working in this study is designed to produce an intermediate grain size in the range 1-5 um without the need for severe deformation. The present paper describes an investigation of the microstructure of a spray cast Al–5.31Mg–1.15Li–0.28Zr alloy and its microstructural evolution during hot compression as a function of temperature.

Example (14) is from a typical Materials Science conclusion:

(14) A high quality Al–5.31Mg–1.15Li–0.28Zr billet with an initial grain size of -10UM has been produced by spraycasting. The Zr micro-distribution was non-uniform, with denuded regions adjacent to coarse L12Al3Zr particles at grain boundaries. After consolidation and dispersoid precipitation heat treatment at 400 deg. C for 4 h the grain size coarsened.

A different style is apparent in the following Computer Science and Neuroscience extracts. Example (15) is from a Computer Science discussion section:

(15) The main advantages of CVA compared to HMM are that CVA is easy to implement and does not require such complex operations as HMM. If one wants to avoid the burden of calculation of probability density functions while building a classifier, CVA is a reasonable choice. But in the CVA method, a whole utterance is treated as a single vector instead of a sequence of independent vectors. Therefore, the number of parameters in CVA is larger.

The last extract is from a typical Neuroscience conclusion:

(16) phMRI is an exciting new non-invasive approach to study receptor function in healthy, diseased and treated subjects. It is the only non-invasive imaging approach that allows mapping of pharmacological interactions in vivo with a high spatial and temporal resolution (Borsook et al., 2006). Developing imaging approaches that will allow in vivo monitoring of cell transplants is essential to advance this therapeutic approach efficiently into clinical practice (Modo et al., 2004). The use of phMRI to assess disease and treatment will surely provide exciting novel insights.

One method or further examining and helping to explain the much lower rate of occurrence in these two disciplines would be to do a text analysis of contrasting examples with the same discourse function or sub-function in different RA sections, for example introduction-discussion-conclusion, and investigate to what extent authors achieve these functions using linking adverbials. However, this particular area of extended research is beyond the scope of the present study.

Some of the many significant discipline differences with individual forms may be explained by a presumed interchangeability of some of the forms. For example, Economics used "rather" far less often and "otherwise" far more often. Yet for two disciplines, this does not explain the variation: Management and Materials Science authors did not use any contrast/concession forms more often.

7.1. Pedagogical implications

Linking adverbials seem to be important, and these results have implications for teaching ESP and particularly for the teaching of research writing, especially dissertations and research papers. It is suggested that competence in research writing includes a developed knowledge of linking adverbials, i.e. when, where and how to use them. This knowledge varies across disciplines and this implies that an awareness of discipline variations is necessary for teachers of research writing. Certainly students must be told of the importance of context in using linking adverbials in research writing, and be told that awareness of their use is necessary[4].

7.2. Further research

More complete lists of linking adverbials need to be developed, perhaps combining lists used in previous research, forms found in dictionaries and a thesaurus, and forms found inside RAs. The latter method may be especially useful. Other questions to research are: How frequent are linking adverbials in other disciplines, and how are they used? What other functions do they have across disciplines? How and when are they acquired by research writers? Exactly how do they function when they cluster together in long and complex sequences? How do Chemistry and Materials Science authors achieve certain functions?

This study shows the importance of linking adverbials in RAs in the sciences

versus non-sciences, and also in individual disciplines. It is proposed that linking adverbials are more important in RAs as signalling and cohesive devices, and for helping authors manoeuvre more effectively to make and/or to strengthen claims, than previously thought. Also, different disciplines achieve this in significantly different ways, confirming the importance of discipline variation when researching their use, and adding to knowledge of ESP. It is hoped this study helps us better understand scientific expression and the RA.

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Matthew Peacock teaches in the Department of English at the City University of Hong Kong. His research interests include English for Specific Purposes, corpus analysis, research writing, genre analysis, and TEFL methodology. He co-edited (with John Flowerdew, 2001) a collection from Cambridge University Press, *Research Perspectives on English for Academic Purposes*.

NOTES

1. Liu (2008) offers a useful review of the literature on the two types of linking devices.

2. See Silver (2003) for further research on stance adverbials.

3. Many authors stress the importance of doing this: for example frequency is obtained from statistical analysis but context is vital in understanding function (Tognini-Bonelli, 2004), and a "microscopic study" must be carried out before categorisation can be done (Williams, 2002: 60).

4. See Bolton, Nelson and Hung (2003) and Chen (2006) for further ideas on teaching.

Appendix: Journals in the corpus

Science

Chemistry
- *Analytica Chimica Acta*
- *Inorganica Chimica Acta*
- *Journal of Organometallic Chemistry*
- *Journal of Solid State Chemistry*

Computer Science
- *Computers in Human Behavior*
- *Computer Speech and Language*
- *Information and Software Technology*
- *International Journal of Human-Computer Studies*

Materials Science
- *Acta Materialia*
- *Biomaterials*
- *Corrosion Science*
- *Polymer*

Neuroscience
- *Cognition*
- *Brain and Cognition*
- *Neuropsychologia*
- *Neuroscience*

Non-science

Economics
- *Economic Modelling*
- *Journal of Economic Behavior and Organization*
- *Journal of Economics and Business*
- *Journal of Financial Economics*

Language and Linguistics
- *English for Specific Purposes*
- *Journal of English for Academic Purposes*
- *Journal of Second Language Writing*
- *System*

Management
- *Journal of Business Venturing*
- *Journal of International Management*
- *Industrial Marketing Management*
- *International Journal of Information Management*

Psychology
- *Acta Psychologica*
- *Cognitive Psychology*
- *Journal of Anxiety Disorders*
- *Journal of Research in Personality*