A STUDY OF SECTION HEADINGS IN COMPUTING, ROBOTICS AND TELECOMMUNICATIONS RESEARCH ARTICLES

CARMEN SOLER MONREAL
LUZ GIL SALOM
MARÍA CARBONELL OLIVARES
Departamento de Lingüística Aplicada
Escuela Técnica Superior de Informática Aplicada
Universidad Politécnica de Valencia

Abstract

In this study we analyse section headings and subheadings of 40 research articles (RAs) in the fields of computing, robotics and telecommunications to identify their macro-structure. Our findings reveal that the standard Introduction-Method-Results-Discussion (IMRD) model described by Swales (1990) as the prototypical structure of the RA cannot account for all the specific choices regarding organization and headings of individual RAs. Scientific writers split the information into a variable number of sections and subsections and combine generic headings with unconventional ones. Generic and partially generic section headings and subheadings help the reader understand the way the writer presents and organizes contents. But when the terminology is topic-specific and does not indicate the rhetorical function of the sections, it is necessary to consult the abstract or the introduction and study the overall purpose of the RA to recognize its organizational pattern. However, a certain cyclical or symmetrical structure at the lexical and syntactic levels is usually kept in different sections.

Key words: genre analysis, macro-structure, research article, section headings

Resumen

Este trabajo analiza el desarrollo de la macroestructura a partir de los títulos y subtítulos de las secciones de un corpus de 40 artículos de investigación de revistas científicas de informática, robótica y telecomunicaciones. Aunque algunos artículos reproducen el esquema Introducción-Método-Resultados-Discusión (IMRD) descrito por Swales (1990) como la estructura prototípica del artículo de investigación, destaca el número de artículos que presentan variantes. La información aparece segmentada en secciones y subsecciones combinando títulos genéricos y títulos no-convencionales. Los genéricos (y parcialmente genéricos) orientan al lector sobre la manera en que se presenta el esquema organizativo escogido por el autor. Pero cuando la terminología refleja el contenido específico de la sección o subsección y no su función retórica, resulta necesario recurrir al resumen o a la introducción y buscar el propósito general del artículo para averiguar cómo está estructurada la información. Con todo, se suele mantener una cierta coherencia mediante la simetría o ciclicidad léxica y sintáctica de los títulos y subtítulos de las secciones.

Palabras clave: análisis del género, macroestructura, artículo de investigación, títulos y subtítulos de las secciones

Recibido el 27-06-2006
RæL 5 (2006): 1-26
ISSN 1885-9089

1. INTRODUCTION

Over the last 25 years there has been an increasing interest in the study of genre. The most extensively analysed genre of academic writing has been the research article (RA) and much research has been carried out on its organizational pattern. A number of studies have been devoted to validate and complete the Introduction-Method-Results-Discussion (IMRD) model, used by Swales (1990) to account for the rhetorical structure of academic texts, in particular for the RA. Such studies have either dealt with the overall organization of RAs from different disciplines and lexico-grammatical features (Swales & Feak 1994; Nwogu 1997; Posteguillo 1999; Ruiying & Allison 2004), or focused on specific RA sections, such as introductions (Swales 1981; Swales 1990; Dudley-Evans & Henderson 1990; Samraj 2002), results sections (Thompson 1993; Brett 1994) and discussions (Hopkins & Dudley-Evans 1988; Holmes 1997; Skelton & Edwards 2000; Ruiying & Allison 2003).

But there has been little research on the connection among different sections and how section headings contribute to it. To our knowledge, no study is concerned specifically with the significance of section headings as rhetorical elements or linguistic pointers of the structure and contents of academic texts from a reader-oriented perspective. Instead, the literature on academic writing makes reference to section headings in order to describe the macro-structure of texts, or particular sections of texts. For example, in their study on the macro-structure of RAs from a functional perspective, Ruiying & Allison (2004) mention the fact that a section heading is not always explicit about the rhetorical function of a section (2004: 265). They distinguish between conventional and unconventional section headings (e.g., *Introduction, Theoretical Basis, Literature Review, Method, Results, Discussion*, etc. and *Context,*

Recibido el 27-06-2006
RæL 5 (2006): 1-26
ISSN 1885-9089

Theoretical Framework, Theoretical Background, respectively, Ruiying & Allison 2004: 270), but they also find differences in authors' uses of conventional headings. Another study dealing with section headings is Bunton's work on generic moves in Ph.D. thesis introductions (Bunton 2002). Although the focus of his research is not on sections headings, he uses the distinction between generic, partially generic and topic-specific headings to comment on the move-step organization of introductions. According to him (Bunton 2002: 64), section headings are generic when they can be used in an Introduction, Method, Results or Discussion section on any topic and discipline, e.g. *Significance of Study* or *Organization of Thesis*. Partially generic headings are those where X is a particular topic of the study, as in *General Review of X Methods*, while topic-specific headings relate to some aspect of the research topic. Since sections reveal how writers view the structure of their texts, the terminology employed in the title of each section should serve as a guide to the reader into the organization of the text. Such is the starting point of the study we present here: to determine to what degree section headings and subheadings contribute to help the reader understand the rhetorical organization of texts.

This paper seeks to describe a set of RAs written in English through the analysis of the terminology employed in the titles of sections and subsections. Our study will try to assess if the standard IMRD model can account for all the specific choices regarding organisation and headings of individual RAs. This will allow us to conclude on the use of unconventional section headings and subheadings and the kind of information they convey, at the rhetorical and conceptual levels.

2. METHODOLOGY

Recibido el 27-06-2006
RæL 5 (2006): 1-26
ISSN 1885-9089

In order to carry out our study, we created a corpus of 40 RAs selected from leading scientific journals in the fields of computing, robotics and telecommunications. The corpus comprises RAs written between 2002 and 2003: 12 RAs in the specific discipline of computing, 16 RAs from journals in the field of robotics and 12 RAs in telecommunications. The main reasons for choosing the journals in our corpus were that they are included in the Science Citation Index (SCI®), they are read by university lecturers and students, and it is in these journals where lecturers and postgraduate students try to publish their research. In an appendix at the end of this paper a full reference list of the texts analysed is included. We shall refer to each RA with an abbreviation that contains the acronym of the title of the journal and a number. RAs are numbered according to their date of publication, as illustrated with the following RAs from the journal *ACMTransactions on Computer Systems (ACMTCS)*:

Journal title: *ACMTransactions on Computer Systems (ACMTCS)*

Acronym	*Article*
ACMTCS1	"Design and Evaluation of a Conit-Based Continuous Consistency Model for Replicated Services". Vol.20 No3 August (2002) 239-282.
ACMTCS2	"Run-Time Support for Distributed Sharing in Safe Languages". Vol.21 No1 February (2003) 1-35.
ACMTCS3	"Lightweight Probabilistic Broadcast". Vol.21 No4 November (2003) 341-374.

The next step in our research was to extract the macro-organization of each text. Then we analysed the terminology employed in the section headings and subheadings with reference to the widely accepted IMRD framework. When the titles were explicit about their rhetorical functions, it was easy to establish the correspondence with the IMRD model. But when the titles were content-based, i.e. they related to some aspect of the research topic, the function of a section and subsection was identified by

Recibido el 27-06-2006
RœL 5 (2006): 1-26
ISSN 1885-9089

consulting the abstract or the introduction and studying the overall purpose of the RA. We labelled the different section headings and subheadings as generic, partially generic and topic-specific (following Bunton 2002).

3. RESULTS AND DISCUSSION

We found that the 40 RAs in our corpus are divided into a number of sections ranging from 4 to 12: 6 RAs present a 4-section structure; 4 present a 5-section structure; 13 are divided into 6 sections; 9 had 7 sections; 3 had 8 sections; 2 present 9 sections, and 3 other RAs have, respectively, 10, 11 and 12 sections.

Only 2 RAs reproduce the conventional generic section headings in the prototypical 4-section structure (IMRD) RAs. They share the opening section heading *Introduction*. However, RAS3 presents the sections that follow with the titles *Materials and Methods, Results* and *Discussion*, while AI3 gives them the headings *Model, Results and Discussion* and *Conclusion*. The function of the generic heading *Materials and Methods* in RAS3 is evident and we can consider that *Model* in AI3 is equally clear as to the communicative purpose of the section. This term is not unusual in the fields of artificial intelligence and telecommunications as new or improved models are often proposed. Moreover, according to the conventional organizational pattern, the Results section of a RA is devoted to the exposition of findings, while the Discussion section includes comments on the specific data obtained in the study and the implications for the field. The purpose of sections III and IV in RAS3 is again clearly signalled with the headings *Results* and *Discussion*. The title of the third section of AI3, *Results and Discussion*, indicates that the report of the results will be accompanied with comments.

Recibido el 27-06-2006
RæL 5 (2006): 1-26
ISSN 1885-9089

And the closing section, *Conclusion*, leads us to infer that it will contain a more general view of the study.

But the organizational structure of the remaining 38 RAs in our corpus reveals that it is customary to find some deviation from the standard division, although it is still possible to identify the underlying IMRD structure, as can be seen in (1):

(1) 1. INTRODUCTION
2. APPLICATIONS
3. SYSTEM MODEL
4. CONIT-BASED CONTINUOUS CONSISTENCY MODEL
5. GENERALITY OF THE CONIT-BASED CONSISTENCY MODEL
6. DISCUSSION
7. ENFORCING CONIT CONSISTENCY
8. SYSTEM ARCHITECTURE AND IMPLEMENTATION
9. PERFORMANCE EVALUATION
10. RELATED WORK
11. CONCLUSIONS AND FUTURE WORK
(ACMTCS1)

As this example shows, various sections are found which, as their headings reflect, fulfil the communicative purposes of the moves and steps of each of the four sections in the IMRD model. We will now present our findings referring to the different traditional sections (*Introduction, Method, Results, and Discussion*) in independent tables. These show the section headings found in the same order as they appear in the RAs together with the number of occurrences.

Table 1 below shows the headings found for introductory sections. It is noticeable that the introductions of the RAs studied, corresponding to Swales's Introduction of the IMRD model, may in fact be made up of several sections. The table refers to these sections as *1st section*, *2nd section*, etc. and to their headings as *1st section heading*, *2nd section heading*, etc. The different section headings used to name these introductory sections are listed on the table, and the number of instances found for each of the headings is given.

Recibido el 27-06-2006
RæL 5 (2006): 1-26
ISSN 1885-9089

Section headings	Number of instances
1st section heading	
Introduction	33
Motivation	2
Background	1
Topic-specific heading	1
No heading	3
2nd section heading	
Related work	2
Review of existing methods	1
Literature review	1
Previous work	1
Applications	1
Background	1
State of the art	1
Key technical concept	1
An overview of X*	1
Summary of the work	1
Previous work on X	1
Definition of X	1
Related X research	1
Topic-specific heading	7
3rd section heading	
Related work	1

Table 1. Headings found for introductory sections (* The symbol X is used in this and the following tables to abbreviate partially generic headings, following Bunton (2002), in order to avoid stating the exact words designating specific contents)

We can see that the 40 RAs in the corpus present between 1 and 3 introductory sections (18 RAs have only 1 introductory section; 21 RAs include 2 independent sections and 1 RA contains even 3 sections). The most usual first introductory section heading is the conventional term *Introduction*, although 2 RAs use the heading *Motivation* and 1 RA uses *Background*. Only RCIM1 has a topic-specific heading: *Concurrent engineering*; and we can also mention that the 3 RAs from IEEEN open with several introductory paragraphs although they do not present a specific section heading. Even though this journal belongs to the IEEE series, it does not seem to follow the same norms for publication.

Recibido el 27-06-2006
RœL 5 (2006): 1-26
ISSN 1885-9089

21 RAs add independent sections focusing mainly on either the background or the literature review. The function of these sections coincides with steps 2 and 3 in Move 1 of Swales's Create a Research Space (CARS) model[1] and they appear under generic headings (9 RAs), partially generic headings (5 RAs), and topic-specific headings (7 RAs). These sections appear after the introductory one, although in one case (WN3) the section which gives an account of the work related to the study is in the section preceding the conclusion. In another case (IEEEJSAC2) the second section of the RA is devoted to summarizing the contents of the next sections, which corresponds to Swales's step 3 in Move 3. According to Bhatia (1993), one explanation for the presence of such independent sections may be the relevance of the information they convey.

Table 2 below shows the results corresponding to the sections that were identified as falling under the Method section of the IMRD model. Only 14 RAs dedicate 1 section to aspects dealing with the materials and methods used in the study, while 10 RAs have 2 sections, 8 present 3 sections, 3 have 4 sections, 2 include 5 sections and 1 RA has even 7 sections. This amount of sections and, consequently, of space devoted to the description of the elements taken into account and the procedures followed in the study certainly reflects the writers' need to describe their methodology accurately and extensively enough to be accepted as a valid basis for their research.

Section headings	Number of instances
1st section heading	
Method	1
Methods	2
Materials and methods	1
Model	1
Mechanistic models	1
Model and notation	1
Hierarchical architecture	1

Recibido el 27-06-2006
RœL 5 (2006): 1-26
ISSN 1885-9089

Definitions	1
Testbed and experimental task	1
Experimental setup	1
A model for X	1
X model	5
X models	1
X process	1
X approach	1
X search	1
X revision	1
X algorithm	1
An architecture for X	1
X architecture and protocol	1
Architecture of X	1
Quantification of X	1
X scheme	1
Evaluating X	1
Topic-specific heading	9
2nd section heading	
Analytical evaluation	1
Evaluation methodology	1
Learning the model	1
Theoretical predictions	1
Preliminaries	1
X model	2
X method	2
X algorithm	2
X prediction	1
Equations for X	1
Design of X	1
Scheduling rules for X	1
Quantification of X	1
Character of X	1
X visualizations of X	1
Topic-specific heading	8
3rd section heading	
Numerical method	1
Analysis of the method	1
Equations of X	1
X architecture	1
X design	1
X strategy	1
Procedure of X	1
X algorithms for X	1
Topic-specific heading	2
4th section heading	
Performance analysis	1
X strategy	1
Topic-specific heading	2
5th section heading	
Algorithms	1
Evaluation criteria	1
Topic-specific heading	1

Recibido el 27-06-2006
RœL 5 (2006): 1-26
ISSN 1885-9089

6th section heading Topic-specific heading	1
7th section heading Topic-specific heading	1

Table 2. Headings found for method sections

In the first section concerned with methodological issues, 14 RAs contain the words *method/s* and *model/s* in their generic or partially generic headings. These words are usual in RAs belonging to the fields of computing and robotics, while in telecommunications they are not used. Instead, the word typically employed in partially generic headings is *architecture* (4 RAs). 16 RAs employ other partially generic headings and 9 RAs use topic-specific headings. However, in general, the headings used in subsequent method sections are mainly partially generic and topic-specific, focusing on particular aspects relevant to the research presented.

Headings for the sections whose function coincides with the pragmatic or discourse function of the Results section in the IMRD model are displayed in Table 3. In contrast to the tendency observed for the method sections, in our corpus 28 RAs present results in one independent section. The function of this section is easy to recognise in our corpus because of generic or partially generic headings containing the words *results* and *experiments*. However, like in the traditional IMRD Method section, when more than one section is devoted to the exposition of results, authors prefer topic-specific headings, restricting clearly the scope of their research and, at the same time, emphasizing the extent and value of their findings.

Section headings	Number of instances
1st section heading Results Overall results	 3 1

Recibido el 27-06-2006
RæL 5 (2006): 1-26
ISSN 1885-9089

Simulation and results	1
Simulation and experimental results	1
Experiments	1
Experimental results	4
Experiments and applications	1
Simulation studies	1
Simulation results	2
Physical demonstrations	1
Implementation and experience	1
Numerical results	1
Numerical results obtained from X	1
X experiments	1
Experiment X	1
Implementation of X	1
Findings from X	1
Topic-specific heading	5
2nd section heading	
An example	1
Effect of X	1
Experiment X	1
Findings from X	1
Topic-specific heading	4
3rd section heading	
Experiment X	1
Topic-specific heading	2

Table 3. Headings found for results sections

We have observed that in WN2, IEEEN1 and IEEEN2 there is not even one specific section dealing with results and in examples (2) and (3) below experimental results appear as a subsection of the method section. In these and further examples the relevant findings are highlighted in italics.

(2) I. INTRODUCTION
II. QUANTIFICATION OF INSTRUMENT MOTION
A. Laboratory instrumentation
B. Intraoperative instrumentation
III. FILTERING ALGORITHMS
A. Tremor
B. Nontremulous error
IV. SYSTEMS FOR ACTIVE COMPENSATION
A. Design
B. Experimental methods
C. *Experimental results*
V. DISCUSSION
VI. CONCLUSION
(IEETRA2)

Recibido el 27-06-2006
RœL 5 (2006): 1-26
ISSN 1885-9089

(3) …
6. AGE-BASED MESSAGE PURGING
6.1 The principle
6.2 Optimized Ipbcast
6.3 Evaluation criteria
6.4 *Results*
7. FREQUENCY BASED MEMBERSHIP PURGING
7.1 The principle
7.2 Optimized Ipbcast
7.3 Evaluation criteria
7.4 *Results*
…
(ACMTCS3)

It is also worth mentioning that in some cases there is some regularity in the order in which the sections presenting results appear. This happens when the researchers' works involve several proposals or shows results under different conditions. In example (4), the sections devoted to the presentation of a model or protocol (sections III and VI) are followed by sections exposing the results or effects of using it (sections V and VII):

(4) …
III. *NETWORK ARCHITECTURE AND PROTOCOL*
IV. THEORETICAL PREDICTIONS
V. *SIMULATIONS RESULTS*
VI. *FT-TR NODE ARCHITECTURE*
VII. *EFFECT OF UNBALANCED TRAFFIC*
VIII. DISCUSSION AND CONCLUSIONS
(IEEEJSAC3)

Some regularity can also be detected in example (5), although, in this case, the first method section (section III) includes a subsection with the findings obtained (subsection IIIC), and the second method section (section IV), which presents the application of the method in a different context, is followed by an independent section commenting on the results (section V):

(5) …

Recibido el 27-06-2006
RœL 5 (2006): 1-26
ISSN 1885-9089

III. EXHAUSTION PROBABILITY FOR A SINGLE LINK
A. Behavior of exhaustion probability for large capacity
B. Asymptotic analysis
C. *Numerical results*
D. Approximation of exhaustion probability based on asymptotic results
IV. ROUTING AND DIMENSIONING IN A LARGE NETWORK
A. Assumptions regarding the network and traffic
B. Upper bound on exhaustion probability
C. Routing and dimensioning under the asymptotic condition
D. Dimensioning networks for moderate link capacities
V. *RESULTS AND DISCUSSION*
…
(IEEEJSAC2)

However, we cannot explain why results are presented as a subsection of a section in some RAs (example (5) subsection IIIC) and not in others (example (5) section IV), where results are given in an independent section (V). We can speculate that, maybe, results are indeed present in some of the subsections although there is no explicit mention to them in the subheading.

As for the final sections of RAs, they roughly correspond to the IMRD Discussion section. They are shown in Table 4. Their functions are either to comment on the major findings, to come to more general conclusions, or to suggest areas of further research.

Section headings	Number of instances
1st section heading	
Discussion	12
Discussions	1
General discussion	1
Conclusion	9
Conclusions	3
Discussion and comparison	1
Discussion and conclusion	1
Discussion and conclusions	1
Conclusions and discussions	1
Future work	1
Discussion and future work	1
Discussion and future research	1
Conclusion and future work	2
Conclusions and future work	2
Summary and research issues	1
Comparison of X	1
2nd section heading	
Future work	1

Recibido el 27-06-2006
RœL 5 (2006): 1-26
ISSN 1885-9089

Conclusion Conclusions Concluding remarks	3 5 2
3rd section heading Conclusion	 1

Table 4. Headings found for discussion sections

The 40 RAs include 1 final section generally entitled *Discussion/s* (13 RAs) or *Conclusion/s* (12 RAs). Moreover, 11 out of 40 RAs in our corpus have 2 sections with a closing role and 1 RA has 3 sections with this same role, which indicates that the writer considers them to be relevant. Their generic headings make reference to the moves and steps that were identified in the Discussion section by Swales (1990) and Ruiying and Allison (2003), indicating a specific-to-general movement. The first moves refer directly to the study and its findings while the following ones focus more generally on the importance of the study in the field, indicate other parallel and open lines of research and suggest future investigation. According to this, it is easy to understand why the writers of IEEETRA3, CVIUV2 and CVIUV3, have devoted sections 4 (*Discussion*) and 5 (*Conclusion/Concluding Remarks*) to deal with the specific-to-general movement convention. Even more clearly, sections 4 (*Discussion*), 5 (*Future Work*) and 6 (*Conclusion*) in IJHCS1 deal independently with information conveyed through moves identified for the Discussion section by the above cited authors.

Most of the RAs in our corpus have distinct sections devoted to the presentation of results and to their discussion. However, 4 RAs include the discussion in a subsection of the section where findings are presented. Moreover, 7 RAs (IJRR3, AI3, IEEETRA1, IEEEJSAC1, IEEEJSAC2, IEEETB1 and IEEEN3) combine both results and discussion in the same section using the following generic titles: *Discussion of*

Recibido el 27-06-2006
RæL 5 (2006): 1-26
ISSN 1885-9089

Results, *Results and Discussion*, *Experimental Results and Discussion/s*, *Numerical Results and Discussion* and *Simulation Results and Discussion*. In all these cases, a closing section is entitled *Conclusion*.

Another relevant characteristic present in 36 out of the 40 RAs in the corpus is that they incorporate subsections and sub-subsections. Although we found subsections in the introductory and in the concluding sections (10 and 8 RAs, respectively), the subsections and even the sub-subsections appear mainly in the method and results sections, which can again be explained by the writers' concern for specifying and detailing the scope of their research. This also explains the fact that, unlike the section headings, the majority of the titles given to the subsections and sub-subsections are partially generic or topic-specific, thus relating to some particular aspect of the research.

Partially generic headings make the reader aware of the current move or step and, at the same time, guide him/her through the research carried out and the concepts and issues dealt with. Headings in our corpus including words like *background*, *overview*, *review*, *previous knowledge*, *hypothesis*, *problems*, *vulnerabilities* or *need* help us to identify one of the steps in the introduction (cf. CARS model, note 1). Words like *system*, *participants*, *device*, *model*, *apparatus and materials*, *description of models*, *architecture*, *protocol* and *algorithm* indicate that we are dealing with materials. Other words or expressions found, such as *application*, *design*, *procedure*, *strategy*, *analysis*, *evaluation criteria*, *search*, *practice*, *variables*, *constraints*, *assumptions* and *data collection* make reference to the method. *Performance*, *analysis*, *effect*, *behaviour* and *experiment* are related to results. And *comparison*, *guidelines*, *perspective* and *extensions* are associated with the moves in the Discussion section. All these words are premodified or postmodified by clauses referring to particular topics of study, thus

Recibido el 27-06-2006
RæL 5 (2006): 1-26
ISSN 1885-9089

leading to partially generic headings like *Results for the visual search task* in JHCS1; *General problems of modelling visual attention* in AI3; and *The linear arrangement problem* in WN2.

But we found it difficult to identify the IMRD standard pattern in RAs when the terminology is mainly topic-specific. In these cases, although the RAs have introductory and concluding sections, the headings in central sections do not help to understand the writer's purpose, as in example (6):

(6) [introductory section; no heading used]
PROPOSED RESTORATION MECHANISM: THE OXC CASE
RESTORATION IN A GENERAL MESH IP NETWORK
RESTORATION MECHANISMS IN THE DWDM/OADM CASE
CONCLUSION
(IEEEN2)

However, we observed that some cyclical, repetitive or symmetrical pattern of the syntactic structure and the terminology of subheadings in many sections often makes it easier to understand the rhetorical and conceptual organization of the sections. That is, recurrent lexis and repetitive morphological and syntactic patterns in some headings and subheadings of the same RA manifest that the organization of its contents is coherent. In some RAs, coherence is exhibited through total or partial repetition of headings and subheadings; in other cases, by means of lexical alternation of terms pertaining to the same semantic field; in other instances, through morphological variations on the same roots. An example of how coherence is created among subheadings of the same section is shown in (7), where the same grammatical structure is repeated, and related variants of *normal* and *detect* are used in each subheading (*anomaly/abnormal/abnormal*; *detection/detecting/detecting*). In (8), *architecture* and *protocol* are used as belonging to the same semantic field.

Recibido el 27-06-2006
RæL 5 (2006): 1-26
ISSN 1885-9089

(7) …
4. ANOMALY DETECTION
4.1 *Building* an *anomaly detection* model
4.2 *Detecting abnormal* updates to routing tables
4.3 *Detecting abnormal* activities in other layers
…
(WN3)

(8) …
III. NETWORK ARCHITECTURE AND PROTOCOL
A. Network *architecture*
B. Node *architecture*
C. MAC *protocol*
…
(IEEEJSAC3)

In example (9) a MRD pattern is systematically repeated inside 3 sections providing a detailed account of the procedure, results and comments on 3 different experiments:

(9) …
4. EXPERIMENT I
4.1 Data sets
4.2 Questions
4.3 Visualizations and instructions
4.4 *Participants*
4.5 *Procedure*
4.6 *Results*
4.7 *Conclusion*
5. EXPERIMENT II
5.1 Data sets
5.2 Questions
5.3 Visualizations and instructions
5.4 *Participants*
5.5 *Procedure*
5.6 *Results*
5.7 *Conclusion*
6. EXPERIMENT III
6.1 *Participants*
6.2 *Procedure*
6.3 *Results*
6.4 *Conclusion*
…
(IJHCS3)

Recibido el 27-06-2006
RœL 5 (2006): 1-26
ISSN 1885-9089

Here, coherence is kept by repeating the same generic section headings and subheadings. In example (10) it is the repetition of the same subheadings in two different sections presenting results that contributes to coherence:

(10) …
6. AGE-BASED MESSAGE PURGING
6.1 *The principle*
6.2 *Optimized Ipbcast*
6.3 *Evaluation criteria*
6.4 *Results*
7. FREQUENCY BASED MEMBERSHIP PURGING
7.1 *The principle*
7.2 *Optimized Ipbcast*
7.3 *Evaluation criteria*
7.4 *Results*
…
(ACMTCS3)

In other cases subheadings share one or more words. In example (11) only the modifiers of the direct objects vary:

(11) …
6.3 CONSTRUCTING PWI, DWI, AND ADWI SETS
6.3.1 *Constructing a* DWI *set*
6.3.2 *Constructing a* PWI *set*
6.3.3 *Constructing an* ADWI *set*
…
(WN2)

In AI1 subheadings sharing the terms *approximation* and *linear response* contribute to guiding the reader through the presentation of three different approximations dealt with in different sections:

(12) …
3. THE MEAN FIELD *APPROXIMATION*
3.1. The mean field *approximation—linear response*
…
5. ONSAGER'S SECOND ORDER REACTION TERM
5.1. The Onsager *approximation—linear response*

Recibido el 27-06-2006
RœL 5 (2006): 1-26
ISSN 1885-9089

6. THE BETHE *APPROXIMATION*
    6.1 The Gibbs free energy an the Bethe *approximation*
    6.2 Belief optimization
    6.3. The Bethe *approximation—linear response*
…
(AI1)

In IEEETRA3 the section on experimental results contains subheadings where lexical opposition points to the design of the experiments carried out (In vitro *experiments of drilling*/In vivo *experiment*). In this way, subheadings show parallel constructions with opposite meanings, like in example (13):

(13) …
VI. NUMERICAL RESULTS AND DISCUSSIONS
    A. Six-node network
    B. NSF network–*Uniform* traffic
    C. NSF network–*Nonuniform* traffic: *Single-fiber* case
    D. NSF network–*Nonuniform* traffic: *Multifiber* case
…
(IEEEJSAC1)

But inner coherence in the subheadings within a section is frequently manifested in the form of lexical variations in postmodifiers of the same noun, as in *Minkowski sum based on* CH/*Minkowski sum based on* slope diagram (in CAD1) and *Hierarchical selectivity/Hierarchical selectivity from* coarse *to* fine/*Hierarchical selectivity from* far *to* near (in AI3). The variations can also appear in the premodifiers of the same noun, like in WN3 (*3.2* Local *detection/3.3* Cooperative *detection*).

Writers also display coherence through the combination within a particular subsection of the words appearing in previous subsections. In this way the reader can keep track of the development of the subject, as in (14): the last subheading (of subsection 3.5) includes *intrusion*, *detection* and *response*, which are part of preceding subheadings (3.2, 3.3, 3.4).

Recibido el 27-06-2006
RæL 5 (2006): 1-26
ISSN 1885-9089

(14) …

3. AN ARCHITECTURE FOR INTRUSION DETECTION
    3.1 Data collection
    3.2 Local *detection*
    3.3 Cooperative *detection*
    3.4 *Intrusion response*
    3.5 Multi-layer integrated *intrusion detection* and *response*

…

(WN3)

All the subheadings of the RAs in the corpus reflect the concepts and models that have been taken into account, the procedures followed and the results obtained under the principles of accuracy, objectivity and explicitness, which characterise academic scientific and technical discourse (Biber 1989). For this reason, it is surprising to find that in one case, illustrated in example (15), the authors position themselves by using positive evaluative language when presenting the results derived from the application of the network architecture they propose. Although evaluative language is rare among our RAs, a larger corpus could reveal a different tendency:

(15) …

V. SIMULATION RESULTS
    A. Traffic sources
    B. *Excellent fairness* between nodes
    C. Performance evaluation
    D. *Performance improvement*

…

(IEEEJSAC3)

4. FINAL REMARKS

The aim of this paper was to describe a corpus of 40 RAs selected from leading scientific journals in the fields of computing, robotics and telecommunications written in English through the analysis of the terminology employed in the titles of sections and

Recibido el 27-06-2006
RæL 5 (2006): 1-26
ISSN 1885-9089

subsections. We found that the IMRD framework is a rhetorical model typically followed by RA writers in the disciplines of our corpus, at the macro-structure and section heading levels. Yet this does not mean that all the RAs have the same organizational characteristics and unified section headings. It is noteworthy that authors dedicate several sections to each of the four sections in the standard IMRD model. As for headings and subheadings, our analysis reveals a great variety of these to name the traditional four sections. In addition, writers combine generic and partially generic headings with topic-specific ones, particularly in the sections and subsections devoted to describing methods and presenting results or proposing models.

The organization of contents in RAs is then reflected in section headings and subheadings with varying degrees of explicitness. Headings and subheadings seem to indicate not only communicative functions but also key concepts in the different RA sections so as to narrow the scope of the research and enhance the achievements. One explanation for this tendency may be that the reader does not usually read the text thoroughly unless he/she is especially interested in it. A way of helping him/her decide whether the contents of the RA will be of any use to him/her is to indicate clearly what every section is about, not only what its role is. As a result, it becomes difficult in some RAs to establish the rhetorical functions of sections, as headings and subheadings do not reflect them explicitly. However, a variety of morphosyntactic and semantic resources showing recurrent patterns contribute to manifesting and maintaining coherence and are, thus, a valuable means of guiding the reader throughout the organization of the text.

Overall, we can conclude that the discourse or rhetorical functions of the headings in our corpus do coincide with those of the standard sections of the IMRD model. What headings and subheadings contribute is a greater specificity on the contents of such

Recibido el 27-06-2006
RœL 5 (2006): 1-26
ISSN 1885-9089

broad sections. As headings use terminology and concepts referring to the thematic content of the text, they are often obscure as regards the pragmatic or discourse function they perform, but they are probably transparent for the specialist reader that is able to interpret their function without any explicit, generic or partially generic, titles.

NOTES

1.
Move 1: Establishing a Territory
    Step 1: Claiming centrality, and/or
    Step 2: Making topic generalisation(s), and/or
    Step 3: Reviewing items of previous research
Move 2: Establishing a Niche
    Step 1A: Counter-claiming, or
    Step 1B: Indicating a gap, or
    Step 1C: Question-raising, or
    Step 1D: Continuing a tradition
Move 3: Occupying the Niche
    Step 1A: Outlining purposes, or
    Step 1B: Announcing present research
    Step 2: Announcing principal findings
    Step 3: Indicating RA structure
(Swales 1990: 141)

APPENDIX

Corpus

1. Journals and RAs in computing

Journal title: *ACMTransactions on Computer Systems (ACMTCS)*

Acronym	*Article*
ACMTCS1	"Design and Evaluation of a Conit-Based Continuous Consistency Model for Replicated Services". Vol.20 No3 August (2002) 239-282.
ACMTCS2	"Run-Time Support for Distributed Sharing in Safe Languages". Vol.21 No1 February (2003) 1-35.
ACMTCS3	"Lightweight Probabilistic Broadcast". Vol.21 No4 November (2003) 341-374.

Journal title: *Computer-Aided Design (CAD)*

Recibido el 27-06-2006
RæL 5 (2006): 1-26
ISSN 1885-9089

Acronym	*Article*
CAD1	"Improvements to algorithms for computing the Minkowski sum of 3-polytopes". Vol.35 (2003) 1181-1193.
CAD2	"A parametric interpolator with confined chord errors, acceleration and deceleration for NC machining". Vol.35 (2003) 1249-1259.
CAD3	"Mechanistic modelling of the milling process using an adaptive depth buffer". Vol.35 (2003) 1287-1303.

Journal title: *Computer Vision and Image Understanding (CVIU)*

Acronym	*Article*
CVIU1	"Robust parameterized component analysis: theory and applications to 2D facial appearance models". Vol.91 (2003) 53-71.
CVIU2	"Facial asymmetry quantification for expression invariant human identification". Vol.91 (2003) 138-159.
CVIU3	"Locating human faces within images". Vol.91 (2003) 247-279.

Journal title: *International Journal of Human-Computer Studies (IJHCS)*

Acronym	*Article*
IJHCS1	"The effect of spatial layout of and link colour in web pages on performance in a visual search task and an interactive search task". Vol.59 (2003) 327-353.
IJHCS2	"Internet attitudes and Internet use: some surprising findings from the HomeNetToo project". Vol.59 (2003) 355-382.
IJHCS3	"Visualizations of binary data: A comparative evaluation". Vol.59 (2003) 569-602.

2. Journals and RAs in Robotics
Journal title: *Artificial Intelligence (AI)*

Acronym	*Article*
AI1	"Approximate inference in Boltzmann machines". Vol.143 (2003) 19-50.
AI2	"Towards an analytic framework for analysing the computation time of evolutionary algorithms". Vol.145 (2003) 59-97.
AI3	"Object-based visual attention for computer vision". Vol.146 (2003) 77-123.
AI4	"Dynamic belief revision operators". Vol.146 (2003) 193-228.

Journal title: *IEEE Transactions on Robotics and Automation (IEEETRA)*

Acronym	*Article*
IEEETRA1	"Visually guided landing of an unmanned aerial vehicle". Vol.19 No3 June (2003). 371-380.
IEEETRA2	"Toward active Tremor canceling in handheld microsurgical instruments". Vol.19 No5 October (2003). 793-800.
IEEETRA3	"Stem cell harvesting device with passive flexible drilling unit for bone marrow transplantation". Vol.19 No5 October (2003). 810-817.

Journal title: *International Journal of Robotics Research (IJRR)*

Acronym	*Article*
IJRR1	"Artificial muscles: Actuators for biorobotic systems". Vol.21 No4 April (2002). 295-309.
IJRR2	"Persistent passive hopping and juggling is possible even with plastic collisions". Vol.21 No7 July (2002). 621-634.
IJRR3	"Isotropic design of spatial parallel manipulators". Vol.21 No9 September (2002). 811-824.

Recibido el 27-06-2006
RœL 5 (2006): 1-26
ISSN 1885-9089

Journal title: *Robotics and Autonomous Systems (RAS)*

Acronym	*Article*
RAS1	"Real time gait generation for autonomous humanoid robots: A case study for walking". Vol.42 (2003) 107-116.
RAS2	"A multisine approach for trajectory optimization based on information gain". Vol.43 (2003) 231-243.
RAS3	"Developing a robot visual system using a biologically inspired model of neuronal development". Vol.45 (2003) 111-130.

Journal title: *Robotics and Computer Integrated Manufacturing (RCIM)*

Acronym	*Article*
RCIM1	"Implementation of concurrent engineering: A survey in Italy and Belgium". Vol.19 (2003) 225-238.
RCIM2	"Modeling, scheduling and simulation of product development process by extended stochastic high-level evaluation Petri nets". Vol.19 (2003) 329-342.
RCIM3	"Algorithmic selection of a disassembly sequence of a component by a wave propagation method". Vol.19 (2003) 439-448.

3. Journals and RAs in Telecommunications

Journal title: *IEEE Journal on Selected Areas in Communications (IEEEJSAC)*

Acronym	*Article*
IEEEJSAC1	"A Study of waveband switching with multilayer multigranular optical cross-connects". Vol.21 No7 September (2003) 1081-1095.
IEEEJSAC2	"Routing and dimensioning in optical networks under traffic growth models: an asymptotic approach". Vol.21 No8 October (2003) 1241-1253.
IEEEJSAC3	"A slotted MAC protocol for efficient bandwidth utilization in WDM metropolitan access ring networks". Vol.21 No8 October (2003) 1295-1305.

Journal title: *Wireless Networks (WN)*

Acronym	*Article*
WN1	"Quality of service and mobility for the wireless internet". Vol.9 (2003) 341-352.
WN2	"Pushing dependent data in clients-providers-servers systems". Vol.9 (2003) 421-430.
WN3	"Intrusion detection techniques for mobile wireless networks". Vol.9 (2003) 545-556.

Journal title: *IEEE Network (IEEEN)*

Acronym	*Article*
IEEEN1	"Multirate video multicast over the Internet: an overview". January/February (2003) 24-29.
IEEEN2	"An agile optical layer restoration method for router failures". March/April (2003) 38-42.
IEEEN3	"Study on a joint multiple layer restoration scheme for IP over WDM networks". March/April (2003) 43-48.

Journal title: *IEEE Transactions on Broadcasting (IEEETB)*

Acronym	*Article*

Recibido el 27-06-2006
RœL 5 (2006): 1-26
ISSN 1885-9089

IEEETB1	"A hybrid CATV/256-QAM/OC-48 DWDM system over an 80-km LEAF transport". Vol.49, No1, March (2003) 97-102
IEEETB2	"Temporal compensated motion estimation with simple block-based prediction". Vol.49, No3, September (2003) 241-248
IEEETB3	"Fast simulation of diversity Nakagami fading channels using finite-state Markov models". Vol.49, No3, September (2003. 269-277.

REFERENCES

Bhatia, V.K. 1993. *Analysing Genre: Language Use in Professional Settings*. London: Longman.

Biber, D. 1989. "A typology of English texts". *Linguistics* 27: 3-43.

Brett, P. 1994. "A genre analysis of the Results section of sociology articles". *English for Specific Purposes* 13, 1: 47-59.

Bunton, D. 2002. "Generic moves in Ph.D. thesis introductions". *Academic Discourse*. Ed. J. Flowerdew. London: Longman. 57-75

Dudley-Evans T. & W. Henderson. 1990. "The organisation of article introductions: Evidence of change in economics writing". *The Language of Economics: The Analysis of Economics Discourse. ELT Documents 134.* Eds. T. Dudley-Evans & W. Henderson. Modern English Publications and The British Council. 67-78.

Holmes, R. 1997. "Genre analysis and the social sciences: An investigation of the structure of research article discussion sections in three disciplines". *English for Specific Purposes* 16, 4: 321-337.

Hopkins, A. & T. Dudley-Evans. 1988. "A genre-based investigation of the discussion sections in articles and dissertations". *English for Specific Purposes* 7, 2: 113-122.

Nwogu, K. N. 1997. "The medical research paper structure and function". *English for Specific Purposes* 16, 2: 119-138.

Recibido el 27-06-2006
RæL 5 (2006): 1-26
ISSN 1885-9089

Posteguillo, S. 1999. “The scientific structure of computer science research articles”. *English for Specific Purposes* 18, 2: 139-160.

Ruiying, Y. & D. Allison. 2003. “Research articles in applied linguistics: Moving from results to conclusions”. *English for Specific Purposes* 22, 4: 365-385.

Ruiying, Y. & D. Allison. 2004. “Research articles in applied linguistics: Structures from a functional perspective”. *English for Specific Purposes* 23, 3: 264-279.

Samraj, B. 2002. “Introductions in research articles: Variations across disciplines”. *English for Specific Purposes* 21, 1: 1-17.

Skelton, J. & S. Edwards. 2000. “The function of the discussion section in academic medical writing”. *British Medical Journal* 320: 1269-1270.

Swales, J.M. 1981. *Aspects of Article Introductions (Aston ESP reports Nº 1)*. Birmingham: University of Aston. The Language Studies Unit.

Swales, J.M. 1990. *Genre Analysis: English in Academic and Research Settings*. Cambridge: Cambridge University Press.

Swales, J.M. & C.B. Feak. 1994. *Academic Writing for Graduate Students. A Course for Non-native Speakers of English*. Ann Harbor: The University of Michigan Press.

Thompson, D.K. 1993. “Arguing for experimental ‘facts’ in science”. *Written Communication* 10: 106-128.

Recibido el 27-06-2006
RæL 5 (2006): 1-26
ISSN 1885-9089