CASE STUDIES OF ACADEMIC WRITING IN THE SCIENCES:

A FOCUS ON THE DEVELOPMENT OF WRITING SKILLS

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CASE STUDIES OF ACADEMIC WRITING IN THE SCIENCES: A FOCUS ON THE DEVELOPMENT OF WRITING SKILLS

The aim of the present thesis is to make a longitudinal study of changes affecting sentence-initial elements in articles published over time by a sample of researchers in international journals of physics. The linguistic framework adopted for such a study is a systemic-functional one. The general research methodology is established around two main axes, one linguistic, and the other statistical. To conduct a longitudinal survey focussing on thematic changes, it was necessary on the one hand to set up clear and unambiguous linguistic categories to capture these changes and, on the other, to present and interpret the findings in manageable and reliable ways with the assistance of statistics.

A pilot study was initially set up to explore possible changes in two articles published within a two year interval by the American Physical Society. The articles were the first and the last of a series of five articles written by the same researcher on the same problem in physics. The method of analysis of the texts used a formulation of Theme that included Subject as an obligatory component, and Contextual Frame – i.e. pre-Subject elements - as an optional one. The analysis, using taxonomies proposed by Davies (1988,1997) and Gosden (1993, 1996), suggested differences in thematic elements, especially regarding a certain type of complex Subject.

On the basis of coding difficulties and the findings of the pilot study, taxonomies were modified to include in particular new Conventional and Instantial classes for Subject and Contextual Frame. Conventional wordings, both in Subject and in

Contextual Frame position, are identified as being expressions which are readily available to novice writers of articles, because they are commonly used terms in the fields of research concerned. In contrast Instantial wordings are identified as being expressions which have been especially contrived by the writer to fit a given stretch of discourse. As writers develop and make their own the matter with which they are working, they become increasingly capable of crafting these more complex wordings which involve multiple strands of meaning. In the case of this latter class, particular reference is made to post-modification and clause-type elements which allow meanings to be combined in specific ways.

The new taxonomies are applied to the linguistic analysis of an extended corpus of physics papers published in international journals by ten different researchers. For each researcher a first and two later papers were chosen. Statistics are used to examine the findings of the extended corpus analysis. Statistical models for each class are constructed which describe trends in Subject and Contextual Frame choices as researchers gain experience.

An interesting finding is the differing behaviours of Instantial wordings according to whether they are in Subject or in Contextual Frame position. This suggests that as researchers gain experience, they become increasingly capable of moulding the more complex Instantial Subjects needed to express the kind of information they want to pass on to their research community. As Subjects start incorporating increasing degrees of complexity, a natural outcome seems to be not to burden the reader with similarly intricate Instantial Contextual Frames. Experienced researchers appear to opt for concentrating complex meanings, whose best position is in Theme, in Subject rather

than in Contextual Frame position. Quite the reverse happens for the more commonly used linguistic expressions represented on the one hand by Conventional Subjects, which decrease, and on the other by Typical and Conventional Contextual Frames, which increase. Results thus suggest that there will be a tendency for more expert writers to make full use of the Subject slot for expressing complex meanings, and of the Contextual Frame slot for simpler and often obligatory pre-Subject elements that are crucial for optimum text flow.

Pedagogical applications of such findings can help raise researchers' awareness of how their published work compares with that of leaders in their field, not only regarding results per se, but also regarding ways of presenting them. Researchers publishing their first papers are acutely aware of the importance of mastering optimal writing strategies in a highly competitive publishing arena. Rather than just seeking advice at the editing level, there comes a point when they want to discuss composing processes. A greater focus on thematic elements in general and on Subject in particular may be a very effective way of helping, especially when time is short and the pressures to publish are great.

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Chapter 1 Introduction

1.1 Aims and Purposes

1.1.1 A longitudinal approach to the study of the research article

The aim of the present thesis is to undertake a longitudinal study of changes affecting sentence-initial elements in articles published over time by a sample of researchers in international journals of physics. Growing interest in the research article has given rise to a number of linguistic analyses of such texts. Work that should be mentioned is for instance Swales´ pioneering study in 1981 on article introductions and his book published in 1990 on English in research settings. Other classics are Bazerman's (1984,1988) studies of the experimental article in science, and Myers' (1985, 1990) studies on the process of writing biology articles, focussing more specifically on changes in scientific claims.

In the vein of recent discourse functional perspectives, Halliday (1998) poses fundamental questions on the different ways in which the language of science 'regrammaticises' experience by means of grammatical metaphor, while Bazerman (1998) has pursued research interests in the direction of the constant creation in science of new concepts.

Functional accounts which centre on particular linguistic features can be found for instance in Gosden (1996), whose findings indicate that the textual metafunction of Theme has an important role in characterising the genre of the scientific research article. He suggests that within this genre, Theme selections are dictated by the changing

rhetorical purposes particular to the different parts of the research article. Swales et al (1998) consider the role of imperatives in articles. Findings show that imperatives may be used for purposes as varied as engaging the reader, reducing text length, or manifesting authorial presence. Regarding recent work related to Subject, Tarone et al (1998) have studied the use of active and passive voice in two research articles in astrophysics, finding that *we* plus an active verb is at least as frequent as the passive in both articles. McKenna (1997) has classified Subject in unmarked Theme sentences using the Gosden (1996) and Davies (1988) taxonomy to examine the writing up of facts in three engineering reports. McKenna finds a small proportion of interactive Subjects and claims that these are less important in these reports than in research articles because engineers would not need to position themselves within a discourse community.

Other scholars have compared research articles in different disciplines, such as work by Hyland (1998) on metadiscourse in seven articles each from microbiology, marketing, astrophysics and applied linguistics. Preliminary findings suggest there are differences in the type of metadiscourse used according to the field of research. However, Hyland stresses the need for further research on the effects of disciplinary context on metadiscourse. Thetela (1997) compares ways of evaluating in articles from history, economics, psychology and applied linguistics. Interestingly, her findings suggest that, in terms of evaluating research, research writers from different fields actually choose from a similar set of options.

Other approaches to the comparative study of academic texts are longitudinal ones focussing on writer development. These studies take as their point of departure essays written by students entering university. A pioneering study was presented by Berkenkotter, Huckin and Ackerman in 1989 who analysed three different introductions of assignments written by the same PhD student. By analysing these texts, Berkenkotter et al focused on how this student, who was not familiar with the conventional structure of articles, started acquiring the genre knowledge characteristic of a research community. Latest examples of such longitudinal approaches are Hewings (1999, 2001) and Haswell (2000) who compare essays written by students in their first, and in their third year of academic study. Hewings (1999, 2001) compares the use of grammatical Subject in geography essays, and finds a greater proportion of more 'epistemic[1]' Subjects in third year. Haswell (2000) analyses improvement in college writing by examining essays used by Washington State University to place students into composition courses. Findings show a rise in holistic scores, and in quantifiable aspects such as the mean length of essays which went from 400 to more than 500 words from first to third year.

However, none of the texts analysed in the longitudinal studies above were written in natural settings for a real audience. Student essays are written more specifically for assessment purposes. Haswell (2000) himself asks whether the changes found in such

[1] This nomenclature is taken from work by Peck MacDonald (1992), where differences in academic texts are explored by classifying Subject. She distinguishes between Epistemic wordings in Subject position, which have to do with knowledge making elements such as methods, conceptual tools and previous studies in the field of research concerned, and Phenomenal wordings in Subject position, which are the objects of study per se. Peck MacDonald's work will be discussed in more detail in Chapters 4 to 6, where a modified classification system for thematic elements is set up.

texts can truly constitute improvement in writing, and whether they are part of normal adult maturation and development of expertise.

The present thesis, instead of recording longitudinal evidence of change in essays written by students, takes as its base-line the first published article written by physicists who have recently been apprenticed into their discourse community. The corpus is composed of texts directly 'from the work place' as it were, i.e. socially validated texts published in refereed journals for an audience of critical peers. The complete study was made in two stages. First, a pilot study was conducted in order to explore preliminary assumptions, which was then followed by the detailed analysis of an extended corpus. The corpus for the pilot study comprises two research articles of around 5000 words each written by the same researcher with an interval of two years. The extended corpus, which provides the basis for a statistical analysis, consists of 30 articles with an average length of around 4000 words. In order to double check some of the analyses, a further four papers were also analysed. The number of words does not include equations, tables and figures.

1.1.2 A study of changes in Theme choices in the research article

The approach used for analysing changes in research articles is the systemic-functional one associated with the Hallidayan school. This approach considers the clause as made up by three different strands of meaning, 'clause as a message', 'clause as an exchange' and 'clause as a representation'. Systemic functional linguistics sees these three strands of meaning as being not only characteristic of the clause, but also as running through the whole of language. It refers to each strand in terms of

metafunctions, i.e. the textual, interpersonal and experiential metafunctions. Within this approach, when we want to explore more particularly how the clause is organised to express textual meanings we have to examine the system of Theme, i.e. 'the element which serves as the point of departure of the message' (Halliday 1994:37).

This study seeks specifically to identify the different linguistic choices related to Theme writers make as they gain experience in publishing their work. The analysis is based on Theme choice because in genres such as that of the research article in hard sciences there is evidence that what a writer chooses as the 'starting point of the message' provides significant and manageable information for the analyst who has to approach such highly specialised texts (Gosden 1996, Davies 1988, 1997). This can be related to the Moves identified by Swales (1990) who suggests that by thematizing certain types of information writers of research articles can achieve both local and global discourse goals. He gives as an example of local discourse goals, the signalling of 'Moves' within one section of a research article, and, as examples of more global discourse goals, the interplay of interactional and topic-based Themes throughout a research article. A useful outcome of this type of inquiry is its applicability to pedagogical contexts. When teaching English for Academic and/or Specific Purposes, awareness of thematic choices can help researchers consider different ways of presenting their results. In particular, novice researchers may improve their writing and their chances of having papers accepted in international journals by looking at the choices made by more experienced researchers.

1.1.3 Theme in the present study

Fries (1983) notes that the consideration of what is or is not thematic within a given sentence varies. For Halliday (1985, 1994) Theme extends up to the first ideational element. Halliday also considers multiple Themes which can have simultaneously textual, interpersonal and ideational elements. The textual and interpersonal elements are optional, whereas the ideational one is obligatory. One of the difficulties with Halliday's views is that he is not always entirely consistent in what he considers as containing an ideational component, an example being Circumstantials. In the second edition of *An Introduction to Functional Grammar* Halliday is more careful in the way he refers to his metafunctions, and distinguishes experiential and logical elements within the ideational. However, as we shall see in the following chapters, these views raise further questions.

The present analysis will include, following Davies (1988,1997), and Berry (1989, 1995), the grammatical Subject as an obligatory element in Theme. Both Davies and Berry argue that this extension to Halliday's Theme gives it greater pedagogic potential: it is closer to what we feel Theme should be, perhaps because Subject is generally intuitively assimilated to 'what the clause is about'. Davies (1997: 55) thus postulates two potential functions for Theme. One function is the identification of an obligatory Topic, realised by Subject, which can play an important role in achieving continuity and coherence in discourse. The other function of Theme can be to supply an optional Contextual Frame, when there are elements preceding Subject, whose function is to help "the development of Topic as the discourse proceeds ." (Davies 1997:55).

1.2 General Research Questions

The purpose of the present study will be to record changes in the ways Subjects and Contextual Frames are dealt with as writers gain experience in publishing their research. There are several research questions which will need to be discussed.

When embarking on a project of the type proposed here, it is necessary to think about the best way of identifying relevant research questions. These research questions can be generated prior to the experiment being conducted, on the basis of results from previous research, in which case they would fall into the category of preplanned comparisons (Freund and Wilson 1993: 226). Alternatively, they can result from the experiment, in which case they fall into the post hoc category (ibid.).

At the outset of the present thesis, there was no prior longitudinal study of thematic choices in the research article. On the basis of preliminary assumptions, a longitudinal pilot study of two research articles written at different times by the same author was designed in order to explore these assumptions. The findings of this pilot study served as a basis to complete and modify these assumptions, and formulate a set of research questions. These questions were then formally examined on the basis of the statistical analysis of an extended corpus of thirty research articles.

There are eight research questions, one for each of the Subject and Contextual Frame categories in turn. Obligatory Subject, within the framework adopted here, realises the function of maintaining topicality. The function of optional Contextual Frame tends more specifically towards assisting text flow. The present thesis has set up

four Subject and four main Contextual Frame categories. There will be two corresponding Subject and Contextual Frame categories labelled as being 'Conventional' and 'Instantial' respectively, because they share some common characteristics. Another Contextual Frame category, the 'Expressive' one, could be seen as bearing some relation to the 'Participant' Subject category. However, because Contextual Frames have the potential to express a much greater range of meanings than Subjects especially regarding ways of indicating writer presence, it was decided to use the different label of 'Expressive'. There is an extra category in Subject called the 'Discourse' category, and an extra Contextual Frame category which is made up by elements which cannot be Subjects. These are typically in pre-Subject position, i.e. conjunctions and conjunctive or modal Adjuncts[2], and will thus bear the label of 'Typical'.

The first four questions concern Subjects, and the next four Contextual Frames.

Research Question 1 - As scientists gain experience as writers, is there a move towards the selection of Subjects which have been especially fashioned to create new, experiential wordings, and which sometimes may have an added interpersonal strand, i.e. towards what the taxonomy set up in the present thesis has labelled 'Instantial' Subjects?

Research Question 2 - As scientists gain experience as writers, will there be comparatively less evidence of what the taxonomy set up here labelled 'Conventional' Subjects? More precisely, will writers be able to design the kind of experiential

[2] Adjuncts is capitalised following Halliday 1985, 1994.

wordings they need by using Instantial Subjects, and thus resort less frequently to the more conventional and pre-formulated expressions commonly used in their field of research?

Research Question 3 - As scientists gain experience as writers, will they tend to become more visible and use a greater proportion of 'Participant' Subjects? This question is concerned with overt writer presence, particularly when *we* is chosen as Subject. The category was taken from work by Davies (1988, 1997) and Gosden (1996).

Research Question 4 - As scientists gain experience as writers, will there be any noticeable trends in the selection of 'Discourse' Subjects, i.e. will there be changes over time in the use of elements such as *this paper* or *Figure 1* in Subject position. The category was taken from work by Davies (1988, 1997) and Gosden (1996).

Research Question 5 - As scientists gain experience as writers will there be relatively less evidence of Typical Contextual Frames on their own? Will experienced writers tend to fashion more complex 'Instantial' Contextual Frames with multiple strands of meaning sometimes enclosing conjunctions and conjunctive/modal Adjuncts?

Research Question 6 - Will the use of Conventional Contextual Frames remain unaltered as scientists gain experience as writers? Will a given number of these commonly used Circumstantials within particular research fields be necessary for an optimum flow of text?

Research Question 7 - As scientists gain experience as writers, will there be a move towards the use of clause-type Instantial Contextual Frames expressing multiple strands of meaning?

Research Question 8 - As scientists gain experience as writers, will there be a move towards the use of more Expressive Contextual Frames with added interpersonal strands of meaning?.

1.3 General research methodology

The general research methodology is established around two main axes, one linguistic, and the other partly statistical. To conduct a longitudinal survey focussing on thematic changes, it was necessary on the one hand to set up clear and unambiguous linguistic categories to capture these changes and, on the other, to present and interpret the findings in manageable and reliable ways with the assistance of statistics.

1.3.1 Design of the longitudinal study

It was noted above that the present study is longitudinal, which means that the corpus was set up by taking publications written by the same respondents at different time intervals. Because of the characteristics of the present research, which seeks to capture changes in the use of thematic elements in published articles, it was necessary to consider intervals of time running into years between first papers and last papers. A serious problem affecting longitudinal studies is that they tend to suffer case losses, the more so in the case of extended time spans. In order to prevent such loss of information, the present analysis was designed as a retrospective longitudinal study where there was one data collection point for the extended corpus in 1999. That year a set of ten

researchers, selected amongst other things for their experience in publishing research articles, were asked to furnish three articles each which they had written on their own. One had to be the first publication they had written entirely on their own, and another had to be one of their most recent publications written alone. They were also asked to choose an additional article in-between these two. The condition of the chosen article having been written by themselves was necessary in order to be able to capture signs of writer development, which might otherwise have been blurred if the article had been written by several authors with varying degrees of experience.

1.3.2 Design of the new taxonomy

Another important task was the design of coding frames required for the analysis of thematic changes. Each category within a coding frame should be as clear and as unambiguous as possible, as well as being non-overlapping (see for instance Oppenheim 1992: 270-271). During the pilot stage that motivated the present research, it was found that existing classification schemes were sometimes ambiguous, except for two of the original Subject categories, Participant and Discourse, which were retained as such from Davies (1988, 1997).

A first step towards analysing an extended corpus was to draw up new taxonomies on the basis of the ambiguities experienced in the pilot study. This has been done in Part Two of the present thesis. Once new categories were determined in the clearest possible way, frequent checks were introduced in order to try and make the coding as objective as possible.

Because of the type of analysis involved, the coding had to be entirely applied by hand. In all cases the analysis was at least double checked by the author, and then by her supervisor. The procedure was the following: once the text had been analysed and ordered into four columns - see Appendix I-B for Paper F2 - it was printed out. The Contextual Frame and Subject columns were then classified by hand on the hard copy according to the new taxonomies. These hard copies were left aside for a time. Then the same analysis was done again, but this time the author worked directly with the electronic version.

In the case of Contextual Frame, the procedure was slightly different because the analysis was much more intricate due to the many subcategories involved, and thus more difficult to double check. For checking whether the hard copy analysis was consistent, tables with eleven vertical columns for each of the Contextual Frame categories were drawn on the computer. Under each column heading all the elements classified as belonging to this heading on the hard copy were entered for a given paper. There are thus thirty such tables, one table per paper. Appendix I-C shows the table corresponding to Paper F2. By checking for instance Column 3 which corresponds to Conventional Circumstantials of Location, it is relatively straightforward to check whether the coding has been done consistently.

1.3.3 Design of the statistical analysis

The present thesis uses statistics in Part Three in two stages. First, statistical tests are applied to the extended corpus of thirty articles, in order to make sure the articles selected are a representative sample which can provide reliable data for the statistical

analysis. Second, statistics are used to examine the findings of the extended corpus analysis.

In the present research there are no a priori null hypotheses, because there have been no previous statistical analyses studying changes in Subject and Contextual Frame as writers gain experience in publishing research articles. Instead, trends emerge when fitting with mathematical curves the data obtained from the extended corpus. The procedure is the following. Data for each Subject and Contextual Frame category is plotted, and then a curve is fitted through each set of data, giving comprehensive and systematic insights into the way Subject and Contextual Frame choices change as researchers gather experience in writing their research papers. Detailed explanations of the steps taken in the actual analysis of the data is presented where they correspond in Part Three, with step by step illustrations of what is being done.

1.4 Organisation of the present thesis

This thesis contains three main parts. Part One continues after this chapter, and centres on a review of the literature and the pilot study which motivated the present study (Chapters 2 and 3).

We saw above that the research methodology is based on the one hand on setting up linguistic categories to capture writer development and on the other on a statistical analysis of such categories. Part Two sets up the new linguistic categories for coding Subject and Contextual Frame (Chapters 4, 5 and 6), and Part Three carries out the

statistical analysis (Chapters 7, 8 and 9), with a closing chapter on conclusions and suggestions for further research (Chapters 10).

A detailed outline of the thesis is presented in what follows.

Part One: Review of the Literature and Motivation

The review in Chapter 2 centres on systemic functional literature on Subject and Theme, and in particular on the ongoing debate of whether to include Subject in Theme. This debate is particularly relevant to the present work, as the research is based on a Theme analysis of the corpus which includes Subject.

Chapter 3 presents the pilot analysis of Theme which was designed in order to explore preliminary assumptions regarding different Theme choices. This exploration will then provide the means for setting up the research questions. The pilot study compares two research articles on the same topic, written by the same researcher and published in the same journal. The difference between the two is that the first was the very first article the researcher wrote on his own and got published in an international journal at the beginning of his Ph.D. research, whereas the second was published once his Ph.D. was finished and he had successfully published another three articles in between. The pilot study was particularly important in highlighting some of the coding difficulties that had to be accounted for, in order to be able to analyse an extended corpus.

Part Two: Setting up a new framework for coding Subject and Contextual Frame

Chapter 4 sets forth by discussing the coding difficulties encountered in the pilot study and suggesting a solution to these difficulties. It reconsiders the classification developed in the pilot study and compares the original results with those obtained by the new taxonomy proposed here, as a starting point for establishing more reliable categories. It closes by stating the research questions which the extended corpus analysis of thirty articles is intended to explore, i.e. what kind of changes affect choices in the different Subject and Contextual Frame categories over time as writers gain experience in publishing results. Once the procedure leading to new taxonomies has been outlined and the research questions stated, the next two chapters discuss in detail the new criteria for coding Subject (Chapter 5) and Contextual Frame (Chapter 6). With the establishment of research questions and of a more reliable coding frame, the next step in the research is the extended corpus analysis.

Part Three: The statistical analysis of the extended corpus

Chapter 7 sets forth by surveying the different stages involved in the selection of the corpus and performs statistical tests of corpus representativity. Chapter 8 then examines the results obtained for Subject. Statistical models for each category are constructed which describe trends in Subject choices as researchers gain experience. These trends will help towards answering the research questions. A parallel study is presented and discussed in Chapter 9 for Contextual Frame.

Chapter 10 concludes on the interplay of the models resulting from the Subject and Contextual Frame analysis and discusses the trends found for the different categories. This final chapter also suggests ways of exploring further these models of behaviour in the use of Subjects and Contextual Frame .

Appendices

There are two main appendices. Appendix I shows the printed version of one of the papers (Appendix I-A), together with examples of a Subject (Appendix I-B) and a Contextual Frame (Appendix I-C) analysis. For reasons of space only one example of the more than thirty papers analysed is reproduced here.

Appendix I-A is the printed version of the electronic ASCII file of one of the papers. Electronic ASCII files are the form under which researchers in physics have been sending their papers to international journals for publication in the past years. When the researcher had no such electronic version of the text, the text had to be scanned. Paper F2[3] reproduced in I-A is the first such reproducible electronic file in alphabetical order. Papers A1, A2 and A3 had to be scanned because the researcher had erased electronic files. The same happened for Paper E1. There were electronic files for Papers E2 and E3, but they were extremely long and with quite a few figures. This made their reproduction much more cumbersome for inclusion in the present thesis,

[3] Each paper is identified by the first letter(s) of the researcher's surname and a number corresponding to the paper. For instance, A1 identifies the first paper written by Researcher A, A2 the second paper and A3 one of the latest papers written by this researcher. Corpus references appear in two different ways in the bibliography: one by alphabetical order, and the other using the letter and identification system.

amongst other things because an extra computer programme is needed to be able to interpret the figures. Finally, there was no existing electronic file for Paper F1, which left Paper F2 as first in line.

Appendix I-B is the printed version of the Subject analysis of Paper F2. It is one of the thirty-five computer files that were drawn up for analysing Subject, i.e. two for the pilot analysis, thirty for the extended corpus analysis, and three extra papers for double-checking Instantial Subjects.

Appendix I-C is the printed version of the Contextual Frame analysis check of Paper F2. It is one of the thirty-two check files drawn up for Contextual Frame, i.e. two for the pilot analysis and thirty for the extended corpus analysis.

Appendix II contains the corpus data which is worked with in Part Three. The first three appendices correspond to data for Chapter 8 on Subject. Appendix II-A presents the case by case data for the Subject analysis, Appendix II-B the time-ordered data for the Subject analysis and Appendix II-C statistical features of the time-ordered integrated data for the Subject analysis.

The next five appendices, II-D to II-H, correspond to data for Chapter 9 on Contextual Frame, e.g. case by case data, time ordered data and statistical features of the time-ordered data for the four categories and eleven subcategories.

PART ONE REVIEW OF LITERATURE AND MOTIVATION

Chapter 2 Review of literature: Why include Subject in Theme

2.1 Introduction

This chapter focuses on the ongoing discussion which has arisen in recent years in systemic functional linguistics regarding what should be given Thematic status, and, in particular, on whether Subject should be included in Theme or not. Unfortunately, as Hasan and Fries have written in the introduction to their book on Subject and Theme, "It is obvious that SF [systemic functional] linguists lack clarity in their discourse on theme" (1995:xxix, brackets added).

One of the first linguists within the systemic functional framework to propose that everything up to and including the Subject of the main clause should be regarded as Theme is Enkvist (1973). Berry (1996)[4] when discussing in detail the different proposals regarding the extent of Theme refers to the one presented by Enkvist as the 'Subject hypothesis'. As a matter of fact since the end of the eighties Berry herself, when analysing children's writing (Berry 1989), and Davies (1988), when analysing academic writing, included Subject in Theme and both have continued to do so.

[4] This refers to Berry M. 1996 What is Theme? A(nother) Personal View in *Meaning and Form: Systemic Functional Interpretations - Meaning and Choice in Language: Studies for Michael Halliday* Berry M, Butler C, Fawcett R, Huang G (eds) Ablex Publishing Corporation. However, when I actually cite parts of this work, the page number refers to the original mimeo Berry wrote, which was then published by Ablex. The reason for using the original mimeo is that there are no typographical errors concerning superscripts and subscripts, whereas there are quite some such errors in the publication (Berry, personal communication, July 2000).

However, rather than subscribing to Enkvist's original 'Subject Hypothesis', in later articles Berry prefers to say that she adopts a 'preverb hypothesis' in the sense that she bases her view of Theme as the element realised by the portion of a main clause that precedes the verb.

As a starting point to this discussion, in Section 2.2 I will consider Halliday's definition of Theme, which is actually twofold: "The Theme is the element which serves as the point of departure of the message; it is that with which the sentence is concerned" (Halliday 1985:38, Halliday 1994:37). Like all truly seminal ideas, this description has nourished, rather than settled, the debate on the boundaries of Theme within the systemic functional approach. Section 2.3 evaluates Halliday's definition of Subject in detail. Section 2.4 will show that Halliday himself, together with other leading systemicists, is acutely conscious of the limitations of these descriptions.

In the following sections I present different views regarding the relation existing between Subject and Theme, which explain why many systemicists have had doubts regarding the thematic status of Subject. Particularly interesting views are those offered by Matthiessen and Ravelli discussed in Section 2.5. They suggest looking at declarative clauses from a dynamic perspective, where Theme shades into Rheme with Subject still retaining some thematic characteristics. Section 2.6 discusses different interpretations of the Subject-Theme issue, those propounded by Hasan, Fries and McGregor, with a focus on the mappings of Subject onto Theme in declarative clauses.

Section 2.7 presents further arguments in favour of including Subject within Theme based on Davies' work on academic texts. Davies (1988, 1997) departs from Halliday by identifying two potential functions for Theme, one that of obligatory Topic, the basic ideational element of Theme realised by Subject, and the other that of optional Contextual Frame, realised by elements preceding the Subject. Her views are less general than Halliday's, but are particularly well suited to the present analysis of highly specialised texts. Section 2.8 concludes with a discussion of the need for simple and effective criteria that can be applied to the analysis of a variety of texts, including the research article in hard sciences.

2.2 Halliday on Theme

Within systemics there are a number of different positions regarding the delimitation of Theme. A natural starting point, and hence the one I consider first, is the description of Theme given by Halliday in *Introduction to Functional Grammar*. In the first and second editions the initial pages of the chapter where he analyses the clause in its textual aspect (Chapter three: Clause as message) remain unchanged except for one clause. An example of an unchanged passage is the following:

> Following the terminology of the Prague School of Linguistics, we shall use the term Theme as the label for this function. (Like all other functions it will be written with an initial capital). The Theme is the element which serves as the point of departure of the message; it is that with which the sentence is concerned" (Halliday 1985:38, Halliday 1994:37).

The only clause which has been changed is underlined in the citations below:

> the Theme is the starting-point for the message; <u>it is what the clause is going to be about</u>. (Halliday 1985:39).

> the Theme is the starting-point of the message; it is the ground from which the clause is taking off (Halliday 1994:38).

Halliday has always maintained that Theme is the starting-point of the message. But his assertion that it is "that with which the sentence is concerned" (Halliday 1985:38, Halliday 1994:37), or, termed slightly differently "what the clause is going to be about" (Halliday 1985:39) has for many been problematic, and he changes the latter to "it is the ground from which the clause is taking off" (Halliday 1994:38) although in the 1994 edition the previous page still says "that with which the sentence is concerned" (Halliday 1985:38, Halliday 1994:37).

Halliday makes it clear that Theme in English is realized by first position in the clause, but that this is not a definition of Theme. Halliday also remarks that it is actually very difficult to define Theme as such, a problem which will be taken up again in Section 2.4 discussing the 'ineffability' of the Textual metafunction. Moreover, even though the recognition criterion for Theme in English seems straightforward, it is actually not as transparent as it looks. One of the main problems, highlighted for instance by Hasan and Fries (1995:xxx[5]), is that within a systemic-functional approach there are three distinct subcategories of Theme that can be found simultaneously within the same clause, those of Textual Theme, Interpersonal Theme and Topical Theme, the latter deriving from the experiential metafunction.

Halliday and most of his followers, such as Eggins (1994), Butt et al (1995), Thompson (1996) and Martin et al (1997) pose as a principle that

" ...every clause must contain one and only one topical Theme." (Eggins 1994:277)

" ... we look for the first experiential meaning before making the division into Theme and Rheme" (Butt et al 1995: 94)

"The principle to remember is that everything up to and including the first 'topical' (experiential) element will count as the Theme." (Martin et al 1997:28)

Thompson (1996), who also advocates stopping at the first experiential element, remarks that Halliday's way of expressing the meaning of Theme as not only 'the starting point for the message', but also 'what the clause is about' (1985:39) or 'that with which the sentence is concerned' (1985:38, 1994:37) can lead to problems. He gives the following examples to illustrate his point: (Themes are in italics, as in the original):

1 - *For centuries*, yellow canaries have been used to 'test' the air in mining.

2 - *Yellow canaries* have been used to 'test' the air in mining for centuries.

3 - *Miners* have used yellow canaries to 'test' the air for centuries.

He says that sentences 2 and 3 are certainly about *Yellow canaries* and *Miners*, but that the first sentence "also seems intuitively to be 'about' yellow canaries, since that is the Subject of the clause" (Thompson 1996:119, bold added). Aboutness, one way of expressing the meaning of Theme, "makes it hard to distinguish it [Theme] from Subject" (ibid., brackets). This is why, for Thompson, "it is better to keep to the idea of Theme as the 'starting-point for the message' or 'the ground from which the clause is taking off' (Halliday 1994:38)" (ibid.) Thompson does however add that "The idea of 'starting point' will probably still seem rather vague" (ibid.).

[5] Page numbering of the introductory chapter to Hasan and Fries (1995) is with roman numerals.

It is also interesting to note that according to Ravelli (1995), in some of Halliday's earlier work concerning Adjuncts in clause initial position "the topical theme can extend over more than one ideational element. However, this problem is not foregrounded in the 1985 description" (Ravelli 1995:220). Moreover one of the difficulties with Halliday's classification is that while defining ideational as "the representation of experience" (Halliday 1985:53) and as "meaning in the sense of 'content'" (ibid.), he is not consistent in what he considers as containing an ideational component. This is especially significant for Circumstantial Adjuncts, as noted by Davies (1997:78). We shall come back to this particular point in Section 2.7 where Davies' criteria for Subject and Theme are presented.

In the following sections I will comment further on research which seeks to clarify some of the issues related to Halliday's thought-provoking description of Theme, and his ideas on what constitutes the Topical element within Theme. The extension of the boundary between Theme and Rheme and the inclusion of Subject within Theme can help clarify issues related to the way in which the analysis of the texts focussed upon here will be conducted. However, before that, let us briefly recall Halliday's definition of Subject.

2.3 Halliday on Subject

For Halliday the Subject is "something by reference to which the proposition can be affirmed or denied" (1985&1994:76) which means that it is the element "on which the validity of the information is made to rest" (ibid.)

He stresses that the unmarked choice for speakers and/or writers is to make the same item function both as Subject and as Theme, unless there is a good reason for not doing so. As an illustration he uses his famous teapot examples:

> ... if the speaker wants to make the teapot his Theme, and to do so without the added implication of contrast that would be present if he made it a marked Theme (i.e. a Theme which is not also Subject, as in *that teapot the duke gave my aunt*), he will choose an option with *that teapot* as Subject, namely *that teapot was given by the duke to my aunt*. Here there is an integrated choice of an item realising two functions simultaneously: Subject in the proposition, and Theme in the message. (1985:77, italics as in the original)

For Halliday, this type of unmarked selection means that speakers and/or writers are assigning two functions to the same element (in the example above, the teapot): that of starting point of the message and that of 'resting point' of the argument.

I should like at this point to compare the two functions just mentioned above, with Halliday's twofold description of Theme as being both the point of departure and what the clause is about. The legitimate question is what is the difference between the definition of Subject as the 'resting point of the argument' (Halliday 1985, 1994:77) and the description of Theme as 'what the clause is about'. A reply within the Hallidayan framework is that the 'resting point of the argument' can be denied, and this is made clear when a tag, which can be responded to, is added. Nevertheless, an expression such as 'resting point of the argument' does seem to be related in a way to an expression such as 'what the clause is about', both expressions displaying what Halliday felicitously called in his 1988 paper 'the ineffability of grammatical categories'. The following section evaluates arguments relating to the difficulties of describing the three

metafunctions distinguished by Halliday, and in particular how difficult it is to express the Textual metafunction. This is why it is so important to try and find clearer ways of visualising Theme, and of determining what should be the boundary between Theme and Rheme, even though as a consequence some of Halliday's powerful insights are lost. A departure from Halliday will be proposed for discourse-driven reasons in order to analyse the present corpus.

2.4 The ineffability of the Interpersonal and Textual metafunctions

With respect to the categories of Subject and Theme, the systemic functional model has related them to Interpersonal and Textual meanings respectively. Halliday himself has commented on the problems that arise from using natural language as linguistic metalanguage, because natural language's ideational system is just not designed for this task. In his words:

> this can lead to serious misconstructions – such as the following, perpetrated by myself, when I wrote some time ago:
> The Theme in an English clause is the element that is put in first position.
> ... a clause that was intended to say how the Theme in English is to be recognized was taken as a statement of how it is to be defined – one of the most fundamental confusions in linguistics... (Halliday 1988:33).

In the same article, he qualifies the category of Subject as always having been "one of the most obscure and controversial categories in western grammatical theory." (Halliday 1988:34)

For Hasan and Fries "The 'reality' to which such [Interpersonal and Textual] meanings relate 'exists' itself only by virtue of semiotic activity" (1995:xviii, brackets added), which would explain in part why it has been so difficult to define Subject and

Theme, and especially the category of Theme. Moreover, "the semantic value of categories such as Subject and Theme cannot become available if one's scope for evidence is limited to single, simple sentences" and "what is largely semiotically created must be investigated in a semiotic environment, which is, properly speaking, discourse." (1995:xix) Especially for Theme, "the nature of textual meanings can be appreciated only when enough of the textual environment is taken into account to demonstrate the contribution, if any, that Theme might make to textual organisation" (1995:xxviii)

Matthiessen has also commented on the difficulties of interpreting the three metafunctions, and for him the Textual metafunction is probably the most difficult to interpret because of the fundamental difference between this metafunction and the Ideational one:

> The textual metafunction is not a representational one. Consequently, unlike the ideational metafunction, it cannot be turned back on itself to REPRESENT itself. We cannot represent the textual category of Theme in textual terms. Textual categories thus have to be INTERPRETED OUTSIDE THE TEXTUAL METAFUNCTION ITSELF by means of the ideational metafunction. Since it is unlike the ideational metafunction, it is also hard to interpret and represent in ideational terms. (Matthiessen 1992:38, capitals as in the original)

However, the attempt to describe Textual categories with metaphors such as 'point of departure' or 'information flow' are useful first approximations towards more satisfactory descriptions. Moreover, Matthiessen argues that an interesting alternative "is to recognize that the semantic system for interpreting language – or any other phenomenon – is typically expanded by means of ideational metaphors and analogies and then to develop an account that grounds 'point of departure' and other ideational

metaphors of abstract space in a model of textual meaning." (Matthiessen 1992:40, capitals as in the original)

In fact Matthiessen stresses that

> The concept of movement through semantic space is at the foundation of most of the metaphors for construing textual organisation." (ibid.). He also cites the following remark made by Halliday: "We favour metaphors like flow of information, and this suggests an ongoing process without any clearly definable segments. But the flow of information is not an unstructured flow; it is characterized by a periodic movement, a wave-like pattern of peaks and troughs. It is perhaps a swell rather than a flow. (Halliday (1982b) in Matthiessen 1992:41, bold added).

So, following Halliday's suggestion, Matthiessen identifies one particular type of semantic movement – "a movement like a swell consisting of WAVE LIKE MOVEMENTS through semantic space. The textual mode of expression is a wave or pulse with peaks of prominence and troughs of non-prominence." (Matthiessen 1992:40)

Matthiessen's identification of the textual mode as being wave-like will be taken up again and further developed in the next section on dynamic views of language, where Ravelli's dynamic perspective will also be discussed.

2.5 Dynamic views of language

2.5.1 Matthiessen on Subject and Theme

In the previous section we saw that due to inherent limitations of language for creating appropriate meanings, definitions and descriptions offered for Subject and

Theme are limited and have to be taken for what they are, for approximations to what they really represent. We have also just seen that by approaching language in a more dynamic way, these approximations might be improved.

Matthiessen's view of Theme as a wave or pulse leads him to the ensuing idea that "the thematic prominence of the clause gradually decreases as the clause unfolds" (1992:51). Thus for him there exists a 'diminuendo effect' which makes it difficult to actually determine a clear-cut boundary for Theme, which reminds us of Halliday's metaphor of 'flow of information' which suggests "an ongoing process without any clearly definable segments" (Halliday (1982b) in Matthiessen 1992:41 cited above in bold characters).

In the case of marked Themes in declarative clauses, where the Subject has ceased to be part of Theme in Hallidayan terms, Matthiessen specifically notes that this type of Subject "still has some thematic prominence, as indicated by the fact that it may relate to the method of development just as when it is the unmarked Theme of the clause" (1992:51-52). One example he gives is the following (italics and underlining as in the original text):

"*Autumn* passed and *winter* [passed], and *in the spring the Boy* went out to play in the wood. While *he* was playing, two rabbits crept out from the bracken and peeped at him."

Matthiessen comments that in the first sentence of this example there are three successive temporal Themes, the first two unmarked in Hallidayan terms and thus

functioning as Subject, and the last one marked and preceding the Subject *the Boy* "yet the Subject still seems to have some thematic value" (1992:52) and is "retained as Theme in the subsequent clause" (ibid.).

The next example given by Matthiessen is the following (italics and underlining as in the original text):

"And *he* found that *he* actually had hind legs! *Instead of dingy velveteen he* had brown fur, soft and shiny, and *his ears* twitched by themselves."

For Matthiessen "*he*, the rabbit, arguably retains thematic status throughout even though the second sentence begins with a clause whose theme is a marked Circumstantial one ... In this clause the Subject still falls within the diminuendo of the thematic wave" (ibid.)

It is interesting to note that Matthiessen's examples are not limited to single sentences. This reminds us of Hasan and Fries' remark that "the semantic value of categories such as Subject and Theme cannot become available if one's scope for evidence is limited to single, simple sentences." (1995:xix) and that, especially for Theme, "the nature of textual meanings can be appreciated only when enough of the textual environment is taken into account to demonstrate the contribution, if any, that Theme might make to textual organisation" (1995:xxviii)

It is also interesting to compare Matthiessen's examples and comments with Thompson's examples and comments mentioned in Section 2.2. Matthiessen and Thompson adopt opposing solutions to resolve the problem posed by whether to include

the Subject in Theme or not. Whereas Thompson discusses his examples in the light of the second part of Halliday's twofold expression of the meaning of Theme, i.e. 'what the clause is about', and recommends ignoring 'aboutness' and focusing on 'the starting point of the message' to avoid having to include Subject in Theme, Matthiessen suggests that not all the thematic potential is necessarily taken up by the first Ideational element and recommends including Subject. This dynamic view is further developed by Ravelli. Interestingly, she actually focuses on the first part of Halliday's description, 'the starting point of the message' to argue for the inclusion of Subject.

2.5.2 Ravelli on Subject and Theme

It has just been observed above that Ravelli's discussion on extending the boundaries of Theme and Rheme to include Subject is made all the more interesting by the fact that she closely sticks to Halliday's description of Theme as the 'starting-point for the message' or 'the ground from which the clause is taking off' (Halliday 1994:38)", the description he focuses upon in his 1994 *Introduction to Functional Grammar*. We also saw that 'starting-point for the message' is the description Thompson (1996) recommends in order to avoid the confusions with Subject that the other part of the description, 'what the clause is about' can lead to. Nevertheless, Ravelli still argues for extending the limits of Theme.

In general terms Ravelli (1995) proposes a dynamically oriented systemic model for the analysis of language. She applies it to further the understanding of the interplay existing between the Theme, Mood and Transitivity metafunctions and, by means of the analysis of this interplay, she sheds light on the issue relating to how far Theme should extend in a clause.

From her dynamic perspective, the account of choice in language is induced by the syntagmatic axis, because actual choices present in the text are seen as evidence for the availability of possible paradigmatic structures. In her words, "The dynamic perspective reveals the points at which, in an unfolding text, options become available, and the kinds of decisions which have to be made in order to proceed from that point" (1995:188). The points at which options become available need to be identified, to further the understanding of the development of texts, and are thus central to an understanding of how texts move forward in a meaningful way. One of these crucial points is where Theme ends, or, put into other words, at what point the message has definitely 'taken off' and is ready to enter into the Rheme part of the clause.

We have seen above that several researchers strongly feel that the boundaries of Theme should be extended further than the first Ideational element, but then where should those boundaries be set? At this point Ravelli remarks that it is widely accepted that the Process is within Rheme, whereas there is doubt about the extension of Theme. She asks two basic questions. On the one hand, why is there doubt about the extent of Theme, and on the other, why is there certainty about its absolute limit? For Ravelli a dynamic perspective on Theme, Mood and Transitivity as the text unfolds can help to answer these questions. She applies her dynamic perspective to the description and delimitation of Theme in indicative clauses, which is particularly suitable for the present work because these are the predominant type of clauses found in scientific writing.

Theme, seen dynamically, is described in the following way: “any initial element of the clause will be taken to *open* the Thematic path; once a candidate for a topical element is reached, steps into further elements will be taken to close the Theme path and open the Rheme.” (1995:222, capitals as in the original)

In a dynamic analysis of Mood, the identification of Subject is not so straightforward because it is necessary to reach the Finite element to confirm which nominal element functions as Subject. In Ravelli’s terms, “Once a Finite element is reached (and given that a potential Subject element has been identified, that is, that a declarative structure is unfolding), the Mood analysis ceases to be of interest, as further steps must pertain to the Residue.” (1995:223, parenthesis and capitals as in the original)

For Transitivity, “very little can be said about ideational meaning as the path begins to unfold. What can be said will increase as the path continues to develop, and will become most informative when the Process element is reached” (ibid.). What Ravelli suggests is that as the clause progresses there is a tendency for ideational meanings to become more and more informative, and to be most informative as the clause reaches Process.

To illustrate how the interaction of the three metafunctions relate to the delimitation of Theme Ravelli discusses the following example taken from a radio news broadcast:

... and there this morning protesters gathered again after dawn ...

which, for her, "illustrates the concerns raised by Berry and Matthiessen: a Hallidayan analysis of Theme would have to conclude that the Theme path closes after *there*, yet *this morning* and *protesters* seem to be just as much a 'departure point' of the message as is *there*." (1995:224) Both *there* and *this morning* have the *latent potential* in terms of a Mood analysis to function either as Adjunct or as Subject. Within a dynamic perspective it is only once the verbal group is encountered "that the Subject path has been taken up, and so no further expectations are required for the Mood analysis" (ibid.).

At this point it is useful to remember that for Halliday, "in a declarative clause, the typical pattern is one in which Theme is conflated with Subject ... We shall refer to the mapping of Theme on Subject as the UNMARKED THEME of a declarative clause" (1985:44, capitals as in the original). On the basis of this, Ravelli argues that if a fronted complement possesses the latent potential of functioning as Subject, this "gives rise to a parallel expectation that the element has a thematic role to play" (1995:224). In her words "the element is *interpreted* as being thematic, because in the Mood analysis, the same element has the potential to function as Subject. Hence in these cases, the Theme is not in fact 'trailing off' (Matthiessen 1992), but is being constantly revised as the clause unfolds, until the point at which the clause unequivocally moves into Rheme." (ibid.)

Now let's go back to Ravelli's original questions about "Why ... is there doubt about the *extent* of Theme, and why is there certainty to its absolute limit?" (1995:221) and to her claim that a dynamic perspective can help answer them. She reminds us that the three metafunctions "unfold in conjunction with each other" (1995:226) and, at the

same time, that each metafunction "needs to be opened and developed in its own terms." (ibid.) When focussing on a declarative clause she points out the following:

> Ideationally ... there is a sense that the departure point of the clause is not fully elaborated until the Process is reached, and it is the interpersonal structure which gives rise to the expectation that the message is off the ground and ready to be elaborated. Textually, everything up to that critical dividing line can be seen to be thematic; once there is an element which is not only thematic, but also likely to be functioning as Subject, the ideational information is expected to be increased imminently, and the departure point of the message is therefore fully elaborated. (1995:227, bold added)

Thus, for Ravelli, the Subject represents a central element in the clause. Put in these general terms there is nothing new about this, as the function of Subject is that of 'resting point' of the argument, and is the element "on which the validity of the information is made to rest" (Halliday 1985:76). But Ravelli goes one step further with her dynamic analysis, which shows that

> Mood is not only important for identifying the 'resting point' of the proposition, but also for acting as a focussing element in relation to the other metafunctions. The Mood component acts as a hinge between the simultaneously unfolding analyses of Theme and Transitivity; until a potential Subject element is confirmed, the Theme analysis is still relevant, as the message is not yet fully 'off the ground'. (1995:227, bold added).

Ravelli suggests that

> an analysis of textual meaning, in terms of Theme, is highly informative at the beginning of the clause, but [...] trails off as the clause unfolds. On the other hand, the analysis of ideational meaning, in terms of Transitivity, is uninformative at the beginning of the clause, but expands as the clause progresses. Like Theme, Mood has its weight at the beginning of the clause, but in the early stages, is never as informative as Theme, and cuts off abruptly once the Finite is reached. (1995:227).

Ravelli then discusses marked Theme. In her dynamic perspective the marked Theme is actually seen as 'delaying', the final topical Theme (i.e. the Subject), which still functions as Theme "but somewhat differently from the case where it is not preceded by or delayed by other topical elements: the final topical theme has a different 'weight' because of the delay" (1995:228). This view is similar to the one given by a synoptic model, "but the dynamic orientation shows that the process of delaying that topical Theme is also functional in itself" (ibid.) in the sense that, the more a Theme is marked, or 'delayed', the narrower are the possibilities of choice as the clause unfolds.

Ravelli concludes that although "the interaction of the metafunctions merits further exploration" (1995:230) it seems that "the interplay of the metafunctional components can signal significant points of development or transfer of responsibility between metafunctions. While all three are always present, one or two can be highlighted as being more informative or pertinent at particular points in the development of the clause." (1995:230).

In conclusion to this section, dynamic perspectives on indicative clauses do help understand why it is so difficult to define boundaries for Theme. Both Ravelli and Matthiessen agree that this is due to the fact that Subject plays a pivotal role within the clause, which explains why although it is preceded by other ideational elements, it still tends to retain some thematic flavour. Because of this pivotal role Subject can even be seen as an essential breaking point within the sentence, as the border between Theme and Rheme, as the point where the message is finally taking off and where the next step is to select another pivotal element, Process within Transitivity. This is illustrated in

Figure 1 below, where I present a complementary view to Ravelli's, but this time with a heavier focus on Theme.

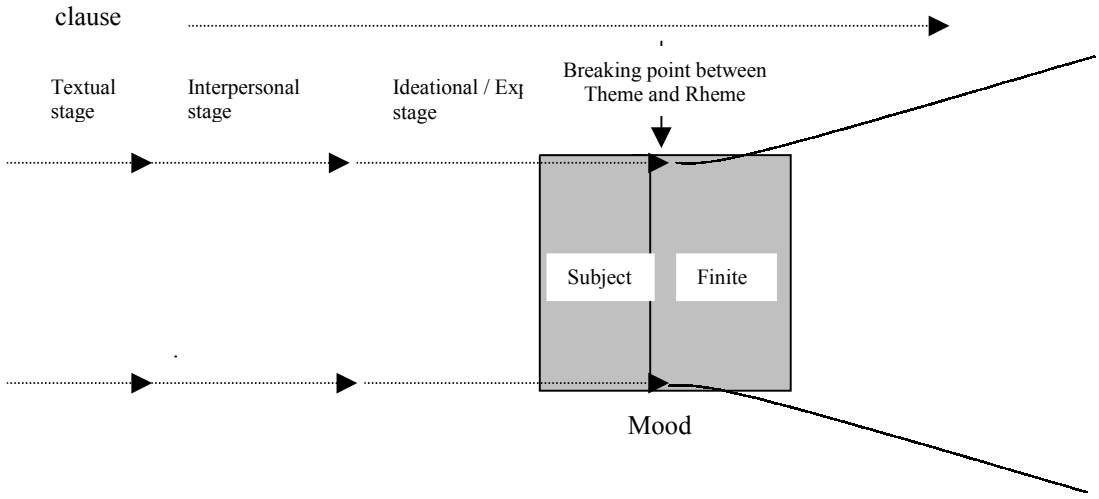

Figure 1 A complementary view of a dynamic perspective of Theme - the grey box represents Mood

2.6 Hasan, Fries and McGregor on Subject and Theme

This section briefly gives added support for including Subject within Theme on the basis of comments by Hasan and Fries (1995) for indicative clauses, and an interesting typification of Topical Theme suggested by McGregor.

We know that the order of Subject and Finite is a grammatical sign of the kind of exchange which is taking place. In the case of the texts analysed here, we have scientists writing up information for their peers by means of statements, and hence Subject comes before Finite. The mappings of Subject onto Theme are extremely common because unmarked Themes in Hallidayan terms will be the Subjects of the clauses concerned.

In this respect Hasan and Fries have made it clear that because Subject systematically comes before Finite in the indicative, and because the mappings of Subject onto Theme are extremely common in that mode of language, Subject becomes relevant when identifying Theme:

"what matters to our discussion here is the fact that in the context of the recognition criteria for topical theme the element Subject is relevant at least in the indicative clause type for stating the meaning of the term *clause initial position* ..." (1995:xxxv, bold added)

For Hasan and Fries it is only "If we assume that marked Themes exhaust the thematic potential of the clause" (ibid., bold added) that we can propound that:

" (i) Everything up to and *including* the element Subject is Theme so long as there is no marked Topical Theme

(ii) Everything up to and excluding Subject is Theme so long as there is a marked Topical Theme" (1995:xxxv-xxxvi).

In other words, the Theme of a clause goes up to and includes the Topical Theme which, for Halliday, "is the first element in the clause that has some function in the ideational structure ..." (Halliday 1985, 1994: 56).

In relation to this, McGregor (1992) when discussing Circumstantials within Systemic-Functional grammar gives as an example *Before very long they heard Lily screaming as though somebody was dead*, where, according to Halliday, the Theme would be the circumstance of time *Before very long*.

However, McGregor does not find the analysis above very satisfactory. To remedy this he suggests that the experiential and logical metafunctions should be distinguished in the structure of the clause. If this distinction is made, McGregor stresses that the way Topical Theme is characterised should be reworded as "the Topical Theme of an English clause is the first element that has an experiential role in the clause." (1992:147, bold added) He then analyses the example above by considering *Before very long* as being "in a logical relation of enhancement to the remainder of the clause." (ibid.) Thus McGregor perceives two Themes, a logical Theme *before very long*, and an experiential Theme *they*:

> The first functions, as it were, to set the scene, relating it to the previous scene (compare Fries 1990; Downing 1990). The second functions to identify what the sentence is about: the *they* referred to, which is not a Theme according to the IFG model. In support of my contention that *they* is indeed a Theme, I would point out first the fact that, in this example, the Senser NP - likewise, an Actor NP in a material process clause - following a Circumstantial element is typically in intuitive terms what the clause is 'about' (in its context of occurrence), and this is frequently identical with the paragraph theme: what the whole paragraph is about. (ibid., references, parentheses and quotation marks as in the original).

McGregor's perspective is particularly useful because not only does he highlight some of the problems attached to the delimitation of Theme, but he also gives an appealing solution to the problem by acknowledging the logical/experiential dimension within the ideational.

Moreover, we have seen in the preceding section that by adopting more dynamic views of the clause as it unfolds, it is easier to understand why it is that when Subject is reached the full thematic potential seems to be exhausted. Within the context of this discussion, Hasan and Fries specifically point out that due to "the special status of the

element Subject in the context of Theme in indicative clauses" (xxxvi) some scholars have argued that "Subject should always be treated as thematic, whether or not preceded by marked Theme" (xxxvi). Hasan and Fries actually stress that in most cases "this alternative recognition criterion for Theme in English does not lead to very different analyses". They do mention the problem of Textual and Interpersonal Themes not always being placed before the Subject, which explains why researchers such as Berry recommend taking Theme up to the verb (the *preverb hypothesis*), but these cases are virtually non existent in the present corpus.

A question posed by Hasan and Fries is: how does the status of Subject as unmarked topical Theme when it follows a marked Theme differ from its status when it stands alone? A partial answer has been hinted at above by looking at the clause as it unfolds: Ravelli sees the marked Subject as having been 'delayed' by other topical elements, thus constraining the possibilities of choice as the clause unfolds. A slightly different and supplementary interpretation offered here is that when Subject follows marked Theme it loses some of its 'thematic force', as it were, as some of it is taken up by what precedes Subject. When Subject stands alone, it embodies all the meaning within Theme, and thus has full 'thematic force'. When it is preceded by other elements, some of the meaning of Theme will be in these other elements. In consequence, "If Theme is a meaningful element on the level of clause or clause complex, then we should find that the kinds of meanings that are made thematic would vary depending on the purposes of the writers" (Fries 1995a:319) and I would add, on the choices they make when writing up. So choosing to put pre-Subject elements is a more 'marked' choice

than just putting Subject. The author has taken the decision of 'framing' the Subject with additional meanings.

An even more interesting question Hasan and Fries ask is "what is gained by claiming that Subject is *ipso facto* also Theme?" As a first approximation, a rather simplistic answer can be that it offers a clearer recognition criterion for the analysis of Theme in the kind of corpus in the present work. The next sections will try and reply to this important issue by discussing yet another view on Subject and Theme, that of Davies (1988, 1997).

2.7 Davies on Subject and Theme

Davies, working with a corpus of academic texts which have some of the characterisitics of those in the present study, extends the boundaries between Theme and Rheme by arguing that Subject should not merely be seen as the unmarked choice of Theme, but as an obligatory element in Theme. Her categorisation of Subject, and of thematic elements preceding Subject, is based on a study of written academic discourse. By being discourse-driven Davies' categorisation might lose in generality compared with Halliday's, but certainly gains in power for the analysis of academic texts. Moreover, it solves part of the problems arising from the ambiguity of some of Halliday's seminal work.

For instance, rather than seeing certain types of Textual and Interpersonal Themes, such as conjunctives and modal Adjuncts, as having to come initially "if they are to be present in the clause at all" (Halliday 1985:56) and the sequence of textual^interpersonal^ideational being "the unmarked one" (ibid.), Davies postulates

that “from a semantic perspective, they may be regarded as a marked choice if they are present” (1997:78). Hence her criterion is not one of obligatory or optional position in Theme, but one of “the presence or absence of the semantic notions expressed in conjunctive and modal Adjuncts” (1997:78). She sees those conjunctive and modal Adjuncts as inherently Circumstantial and proposes that “ ... the marked choice[6] is represented primarily through the presence or absence of a Circumstantial element in Theme and, at a secondary level, through reference to a classification of Circumstantial elements based on functional semantic criteria rather than traditional grammatical class” (1997:78).

Her justification for doing so is that “ ... the distinction Halliday draws between conjunctive and modal Adjuncts [serving the Textual and Interpersonal function], on the one hand, and Circumstantial Adjuncts [serving the Ideational function], on the other, is not one which can be maintained with consistency” (ibid., brackets added) because there is an important degree of overlapping “with this apparently transparent division of functions” (ibid.).

Hence, the constituents of Theme are not categorised with reference to Halliday’s Textual, Interpersonal and Ideational metafunctions, but with reference to the categories of obligatory Subject/Topic, representing the basic Ideational element, and of optional Contextual Frame, preceding the Subject/Topic.

[6] F. Davies’ views on markedness are actually quite similar to Halliday’s, because “he always insisted that if a feature was marked then the point of its being marked was in order to convey additional meaning” (Martin Davies, e-mail, April 13 1998).

The differences between Davies' views on Theme, I illustrate in Figure 2 below, and a more Hallidayan based view I illustrated in Figure 1 above, can be seen when comparing both figures.

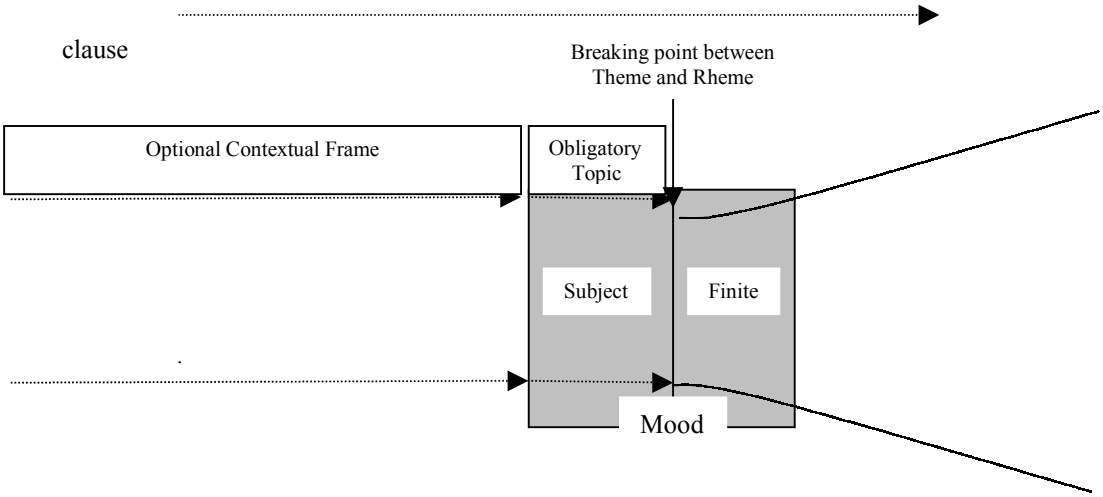

Figure 2 An illustration of Davies on Theme

We can see that in a purely Hallidayan framework, there might exist the possibility of Theme stopping just before the Mood box in Figure 1 if there were to be an Ideational/Experiential element before Subject. Alternatively, if such an element were missing, then Theme would stop at what is marked in Figure 1 as being the 'Breaking point between Theme and Rheme'. Hence the limit between Theme and Rheme is not a hard and fast one, but can be either just before Mood or at the 'Breaking' point, according to whether an Ideational/Experiential element is detected before the Subject. The problem is sometimes whether an element is actually considered as being of an Ideational/Experiential kind. In the Mathiessen and Ravelli dynamic perspectives, there

is however a point after which Theme dies out completely and this is the 'Breaking' point. In contrast, in Figure 2, within the framework offered by Davies (1988, 1997), the breaking point between Theme and Rheme is unequivocally identified. Theme is constituted of two elements, Subject and Contextual Frame, having two distinct functions:

> Subject as an obligatory grammatical constituent of the clause, is seen to serve an equally obligatory semantic function in the clause, that of identifying 'topic'. Thus Subject is equated with the intuitive notion of 'what the clause is about'... Non-Subject thematic elements [i.e. Contextual Frame], by contrast, are seen to serve the distinct function of providing different frameworks or contexts for the development of topic as the discourse proceeds. (Davies 1988:177, square brackets added)

In other words, for Davies, Subject within Theme is an obligatory element and is essential for identifying and maintaining topic continuity in a text. Subject is "the basic ideational element" (1997:55). On the other hand Contextual Frame "realised by elements preceding Subject" (ibid.) is optional and serves not only for fronting additional information about the message, but also for signalling changes within the flow of discourse.

This distinction made by Davies of two distinct functions for Subject and Non-Subject thematic elements enables her to focus on different kinds of thematic choices. Some choices not only constrain subsequent selections within the sentence as the text develops, but also offer "a subtle and powerful device for presenting the writer's viewpoint or stance" (Davies 1988:179) in written academic discourse. In particular, writers can choose to be more or less visible according to the type of Subject they select, and can choose whether to 'frame' that Subject or not, and in different ways.

Davies' systems of categorisation for Subject/Topic and for Contextual Frame will be discussed at greater length in a following chapter. At this point, the following section will summarise the advantages of considering Subject as an obligatory element in Theme for a corpus of highly specialised academic texts.

2.8 Conclusion: what is gained by including Subject in Theme

2.8.1 Functions of Subject and Theme in Halliday (1985, 1994)

This chapter started by discussing Halliday's views of Subject and Theme, related to Interpersonal and Textual meanings respectively, each fulfilling a different *function* in the clause. Within a Hallidayan framework, Martin Davies reminds us that:

> The point of distinguishing between Theme and Subject at all is that they have different functions. The Subject is not about starting-points but about what can be denied: it is the nexus of the proposition, about which the proposition asserts something. It is for this reason that I like to analyse a text in two different ways: one way identifies the Method of Development, identifying the succession of starting-points of each clause, i.e. the way in which the message is developed; the other way identifies the Matter of Argument, the sum of the Subjects about which propositions are asserted. (Martin Davies, personal communication, April 13 1998).

In reply to the large body of research which advocates including Subject in Theme. Martin Davies warns that by doing this some systemicists are "carefully combining what Halliday has carefully separated" (ibid.). For him one thing is to be interested in the mappings, i.e. "when the Subject is mapped on to the Theme, and therefore the wording of the Subject itself also contributes to the Method of Development" (ibid.). Another thing is to study "the contents of the wordings of the Subjects ... since this constitutes the "Matter of Argument"." (ibid.)

2.8.2 Overlappings of Subject and Theme

However, at this point it appears that the ongoing debate concerning the boundaries of Theme has been motivated by factors which obviously present real problems for text analysis, three of which were discussed more at length above. One is the 'ineffability' of the descriptions of Subject and Theme (discussed in Section 2.4), the second is the fact that some Ideational elements do not seem to take up in a satisfactory way all the thematic potential of Theme (discussed in Sections 2.5 and 2.6; just to take one of the examples discussed above, *there* in Ravelli's example *and there this morning protesters gathered again after dawn*), and the third is that the classification of the elements which are Textual, Interpersonal or Ideational is sometimes unclear (discussed in Section 2.7: see Davies' example of Circumstantial elements).

Let us now go back to Figure 1. As the clause develops, we can encounter different stages in Theme, including, from left to right, an optional Textual stage, an optional Interpersonal stage and an obligatory Ideational stage. In Hallidayan terms, if the first Ideational/Experiential element happens to be the Subject, we have an unmarked Theme. If we first encounter any other Ideational/Experiential element, Theme stops at that element and becomes marked. In this case Subject is not included in Theme.

What happens if we depart from Halliday and include Subject as an obligatory element within Theme? We know that in the unmarked case, when Subject maps onto Theme, the analysis remains identical. Very roughly, and as a first approximation, in the present corpus, about seventy per cent of the Themes of main clauses map onto Subject.

More importantly, in the marked case, by including Subject in Theme we increase the 'load' of Ideational meanings within Theme. Instead of having only one Ideational element which takes up all the thematic potential of the clause, we might have more than one, depending upon the presence of Ideational elements before Subject.

At the same time, by including Subject we also increase the load of Interpersonal meanings within Theme. We have on the one hand the optional Interpersonal stage of Theme, which can be present or not, and we have the obligatory Mood element 'Subject', which of course belongs to Interpersonal meanings.

Hence, by including Subject, Theme becomes more loaded with Ideational and Interpersonal meanings. We have a typical case where Ideational and Interpersonal meanings are mapped on to each other, a normal and unavoidable phenomenon in language that systemicists regularly draw attention to. For instance Butt et al point out that "While it is often convenient to think of these language functions separately, they cannot be entirely separated: the fact that they map meanings simultaneously means that they inevitably exert an influence on each other" (Butt et al 1995: 87)

On slightly different lines, this time concerning Textual and Interpersonal meanings, Martin et al make an extremely interesting observation when discussing the Japanese equivalent of *It's hot* which is *Atsui*, "an 'i-adjective' serving as Process and no Theme: the Japanese THEME system is not oriented towards the MOOD system in the way the English THEME system is" (Martin et al 1997:32, capitals as in the original).

Hence, Martin et al suggest that the English Theme system is oriented towards the Mood system, which would in part explain why there has been so much discussion about whether the boundaries of Theme should be set just before the Mood 'box' (first Ideational element in Halliday's marked Theme) or within the Mood 'box' (Halliday's unmarked Theme or when Subject is considered the last and obligatory element in Theme) in Figures 1 and 2 of this chapter. We have also seen that for Ravelli Mood not only identifies the 'resting point' of the proposition, but also behaves as a pivot for the "simultaneously unfolding analyses of Theme and Transitivity" (1995:227).

By including Subject as an obligatory element within Theme, I agree that we are in a way combining what Halliday has separated for functional reasons. We are looking at the Method of Development *and* what Martin Davies (1998) has called the "Matter of Argument". At the same time other systemicists do not necessarily choose to make a clear difference between the 'Method of Development' and the 'Matter of Argument'. Matthiessen specifically notes that in examples such as *Autumn passed and winter [passed], and in the spring the Boy went out to play in the wood*, the Subject *the Boy* "still has some thematic prominence, as indicated by the fact that it may relate to the method of development just as when it is the unmarked Theme of the clause" (1992:51-52). Hasan and Fries on their part stress that in most cases, by adopting the alternative recognition criterion for Theme in English as 'everything up to and including Subject', this "does not lead to very different analyses" (1995: xxxvi). Another important point Hasan and Fries (1995) stress is how heavily dependent the Textual metafunction is upon the flow of discourse. The Textual metafunction is concerned with the Method of Development of the text. This explains why, in the case of certain marked Themes,

systemicists often feel that by stopping at the first Ideational element the analysis might be unnecessarily truncated, and thus might not reflect the Method of Development of the text as a whole.

2.8.3 What is gained by including Subject in Theme

The present corpus is formed by highly specialised texts that need Halliday's powerful framework to be reconsidered for their Theme analysis. An important step is to give the linguist effective criteria for recognising the boundaries of Theme for the purposes of textual analysis and interpretation. One way of achieving this is by including Subject in Theme, especially as we are dealing with declarative clauses where Halliday's seminal distinctions will virtually not be clouded by taking such a step.

Gosden (1996: 79), who worked on such a type of corpus, pointed out that a more workable and transparent view of textual development in the research article in science can be gained by taking Subject as an obligatory thematic component. He thus adopts the more discourse-oriented views of Theme propounded by Davies, driven by a pedagogical need to analyse academic texts. We saw how Davies conceived Theme as being composed of two basic elements, an optional Contextual Frame that provides different contexts for Topic as the text unfolds, and an obligatory Subject that specifies Topic. This conception of Theme is particularly well suited for examining research articles in science, as shown in full by Gosden's work. His interest in using Davies also lies in the fact that Davies is acutely conscious of some of the problems connected with Theme analysis in general, and with Halliday´s treatment of Circumstantials in particular as will be discussed here in Chapter 6. These problems are highlighted when trying to identify 'between overlapping semantic categories and realisations which

appear to serve more than one metafunction, yet which clearly have the same discourse function.' (Gosden 1996:73) Some of these difficulties can be overcome by adopting a more discourse-oriented view of Theme, which also helps to identify its cut-off point.

An added advantage of including Subject in Theme proceeds from the fact that it will tend to increase the amount of comparable wordings analysed. As far as the information structure of the clause is concerned, more given meanings will tend to cluster in Theme position whereas newer ones will tend towards Rheme. More given wordings generally express meanings which are common to certain fields of research precisely because they tend to be given, i.e. Textual and Interpersonal meanings, as well as the more 'given' parts of the Ideational/Experiential meanings present in those texts. Rheme, in contrast, is far more loaded with the kind of new Ideational/Experiential meanings which are entirely specific to a given paper.

Regarding the latter, it is interesting to note that for instance equations are systematically in Rheme position. The role of equations in the grammar of the text is an extremely complex matter which will not be analysed in depth here. Suffice it to say for the moment that "the grammar is actually held in the equations in some peculiar way" (Aitchison[7], transcript of interview, August 22 1997) and this has to do with the fact that "physics actually is about words and mathematics" (ibid.). Physicists have to get the balance right "between the verbal qualitative conceptual description in words/ and the mathematical precise quantitative description in terms of symbols/ hum/ well mathematical symbols because words are symbols too/ but mathematical symbols/"

[7] Professor Ian Aitchison is head of the Department of Physics at the University of Oxford, and the author of numerous research articles and several textbooks in theoretical Physics – mainly Field Theory.

(ibid.). Equations can be seen as bearing the most concentrated load possible of Ideational/Experiential meanings, systematically put in Rheme position.

2.8.4 Final Remarks

In sum, Davies' view of Theme as consisting of an obligatory Subject and an optional Contextual Frame is especially powerful for the analysis of these highly specialised texts. It is often difficult even in everyday language to decide what is 'truly' Interpersonal or Textual or Ideational. There are fuzzy sectors, and decisions might have to be taken on the basis of how a text is interpreted. When dealing with texts such as the research article in physics, the problems are increased because of their highly specialised nature. This in turn implies the need for effective ways of analysing these highly specialised texts, which are offered by Davies' categorisation. It takes into account the multiple meanings present in Theme, but at the same time, whilst taking into account this multiplicity, it does not ask of systemicists immediate and crucial decisions as to what is Textual, and/or Interpersonal and/or Ideational. However, systemicists are instantly made aware of whether Subject is framed or not with additional meanings, and know precisely where to put the boundaries of Theme although texts might be particularly obscure and difficult.

It is now time to turn to the actual analysis of texts. Clause boundaries used for the analysis of Theme will be similar to those used by Martin (1985) in his Thematic structure analysis of The Chaucer essay. His analysis of Theme-Rheme is restricted to paratactic clause complexes because hypotactic clauses often function as Themes themselves, as we shall see in the present corpus. In a similar way Gosden (1996), in his Theme analysis of research articles, comments that his intention is to give a clearer

picture of thematic patterns without the hypotactic interference of secondary organisation. Furthermore in Davies's view (personal communication, 1997) the choice of orthographic unit is deliberate, which would be a further argument for dropping hypotactic clauses and analysing at sentence level as for example Berry (1995) does. In Berry's words 'it would seem sensible to concentrate on those Themes generally agreed to be significant for text organisations and genre-awareness.' (1995:63)

The next chapter presents a preliminary study of Theme which was undertaken at the beginning of this Ph.D. research on the basis of a taxonomy for Subject and Contextual Frame initially devised by Davies (1988) and developed by Gosden (1996). This taxonomy will be modified in following chapters, and a new taxonomy will be used for the main corpus of 30 research articles.

Chapter 3 A pilot developmental study: linguistic choices in two research articles in physics

3.1 Introduction

This chapter discusses a pilot study of Theme which represents a preliminary exploration of the different linguistic choices made by writers of papers as they gain experience in publishing their work. When the research was started, it was decided to survey Theme in the light of Davies' discourse-oriented account of obligatory Subject and optional Contextual Frame. Consequently, the first two research questions that needed to be addressed were the following:

General research question for Subject: As scientists gain experience as writers, are there perceived changes in the choice of Subjects in published research articles?

General research question for Contextual Frame: As scientists gain experience as writers, are there perceived changes in the choice of Contextual Frames in published research articles?

These general research questions, which this pilot study was intended to explore, provided a starting point for establishing on the one hand more specific research questions, and on the other more reliable categories for the study of the evolution of Subject and Contextual Frame. During the course of this pilot study some of the

categories used appeared to be not sufficiently rigorous to capture reliable and accurate signs of writer development, which is why new taxonomies will be developed.

Hence, the motivation for this pilot study is to show how the original Davies (1988) and Gosden (1996) taxonomies worked within the context of a study of writer development. The study aims at clarifying the process that led to more specific research questions and to new taxonomies for studying the main corpus of 30 research articles. Subsequently, once the findings of the extended corpus are obtained, it will also provide a good illustration of the shortcomings that could result from wanting to generalise conclusions based on the analysis of too small a corpus.

Section 3.3 describes interviews undertaken with specialist informants commenting on the texts. It provides a qualitative framework indicating ways in which the articles differ and why. Section 3.4 briefly summarises approaches to the study of Theme adopted for the analysis of the texts throughout this thesis, which were discussed more at length in Chapter 2. Theme is seen as often attracting more given and interactive meanings (Halliday 1994: 36-37, Berry 1995:58, Ravelli 1995:227). These meanings, in the case of highly specialised texts, were suggested in Chapter 2 as being more discipline-independent and manageable meanings. In the present pilot analysis they are classified using the original taxonomies of Thematic elements proposed by Davies (1988,1997) and Gosden (1996). These taxonomies will be modified from Chapter 4 onwards, when the extended corpus of 30 articles will be introduced.

In Section 3.5 systems of choice within Theme for the two texts are identified, always bearing in mind that the taxonomy used in the present chapter is original to

Davies and Gosden. Section 3.6 discusses the findings of the analysis within the broader context given by the interviews. It also points out how its limitations led to new taxonomies.

3.2 Characteristics of the pilot study

As manifested in Chapter 1, the present study, in a similar way to Berkenkotter et al (1991), is concerned with authorial development. However, instead of focussing on how a student becomes a researcher, the starting point is a young physicist[8] who has already been apprenticed into his discourse community by working in research settings. The analysis seeks to identify the different linguistic choices related to Theme which this particular author makes as he gains experience in publishing his work. The texts are published articles which were written in natural settings for a real audience. The study may be compared with longitudinal ones such as Berkenkotter et al's which examine the development of college writing, where students are asked to write contrived texts specifically for assessment purposes, rather than for passing on meaningful information in natural writing settings.

The pilot study analyses the first and the fifth article the researcher wrote on his own, published in 1995 and 1997 respectively, in the same international journal, *Physical Review B*, of the American Physical Society. The articles, which presented the results of his Ph.D. research, were written during a crucial period of development for the young scientist.

[8] The researcher is a male, and thus is referred to as "he". The same occurs later on in the text with an "expert" researcher, also male. For the group of "novices", where there were eight men and one woman, either the plural or "s/he" "her/his" is used. For all the other cases when I speak generically of researchers I also use either the plural or the "s/he" "her/his" forms.

The “novice” researcher in question - “novice” in the sense that he was writing his first research papers for international journals - worked in solid state physics in Argentina. He was a non-native speaker of English, but his mastery of the language was native-like especially regarding academic genres. He followed intensive courses of English for several years and used English daily during the course of his studies in physics, both as an undergraduate for four years and as a graduate student for another four years. In physics the great majority of research papers are published in English. English is also used as a lingua franca by visiting lecturers and researchers.

The study compares the different choices this novice made as he strove to become an “expert”. In order to locate textual findings within the broader context in which a text is composed, several interviews were conducted in English with the author of the articles and other physicists. The author was interviewed on his writing process and on the differences he saw between the two articles. To gain additional insights into the writer’s development, specialist readers were also asked for their opinions on the differences between the abstracts of the articles. Only the abstracts were discussed in detail with specialist readers because the whole articles proved to be far too long to use as a basis for interviews of about one hour each. The interviews are presented in the following section.

3.3 The interviews

This section presents the findings of the interviews with the writer and with other physicists working in areas related to the publications. The writer was asked to compare both articles and his experience of writing them. The other physicists – one expert and nine novice researchers - were asked to compare the abstracts and talk about the

differences they perceived in them. These interviews were aimed at eliciting opinions on the texts by insiders.

The interviews with the author and the expert researcher were recorded and transcribed. Pauses appear in the present text as suspension marks. Written notes were taken of the interviews with the novice researchers. The interviews with the author are discussed below. The ones with the expert and the novices are presented in Subsections 3.3.2 and 3.3.3 respectively.

3.3.1 Interviews with the author of the two papers

Three interviews of about an hour each were conducted with the author on his writing process and on the differences between his first article, hereafter Paper J1, and his fifth, hereafter Paper J2. During the first interview (Interview 1) the author gave general comments on the papers, both of which present research in solid state physics, and in particular results of the same type of numerical simulations applied to superconductivity. In Interviews 2 and 3 the author gave more specific comments on the differences between the papers.

In particular the author said that although both papers presented results from the same superconductivity model using the same kind of numerical simulations, there was a qualitative difference in the results and thus a difference in their organisation. In Paper J2 there is one central result that is presented in the most important figure of the paper. In contrast, there is no central result in Paper J1, but several minor ones. Hence the author felt that when writing Paper J1, the first paper, he had had to "jump around in the text from one result to the next" whereas it had been much easier to organise Paper J2, the last paper, around the central result.

When asked to be more precise about these differences in writing up the two papers, in the author's words,

"it's difficult to... to distinguish between what is... what is due to the... to our understanding of the physics and my capacity to write at this or that moment ..." (Interview 2)

However, he did point out that

"at the level of sentences it was more fluid for me to write this... the last paper than the first one ..." (Interview 3).

By the time the author was writing his fifth paper, the previous four had already been successfully published and were used as citations to back up his latest work. This would perhaps explain why the author said the results in the fifth paper had a stronger scientific basis, and why he had felt more relaxed about writing up these last results.

3.3.2 Interview with an expert scientist

As was mentioned previously, because the complete texts were too long to be discussed in detail with different physicists (both texts have approximately 5700 words each, with many equations and complex figures) the abstracts of each paper were used as a basis for the other interviews. In order to get as wide a range as possible of opinions, two different types of specialist readers were interviewed. First impressions

were asked on the one hand from an expert physicist, and, on the other, from novice physicists who were themselves in the process of publishing their first articles.

The abstracts of the papers were presented to Professor A, an expert informant working in theoretical physics at Oxford University. He is the author of many research articles and textbooks within his field of research, as well as being an editor and referee for publications in theoretical physics. He has supervised numerous PhD students. At the time of the interview he was a visiting professor at the author's workplace in Argentina. He only saw the texts as ASCII files, as they are presented here, without knowing if and when they had been published.

FIRST PAPER: Abstract J1
We calculate numerically the behavior of a model high-temperature superconductor described by a three-dimensional array of Josephson junctions in the presence of an external magnetic field using dynamical Langevin simulations in the extreme type-II case. In particular, the voltage generated when an external current is applied, and its dependence on the external field and thickness of the sample are discussed. We find that the {\it ab-}plane resistivity is well described by a thermal activation model, whereas the {\it c}-axis resistivity appears for higher temperatures. To make connection with recent experiments, the response to non-homogeneous applied currents is also discussed.

LAST PAPER: Abstract J2
We propose a phase diagram for the vortex structure of high temperature superconductors which incorporates the effects of anisotropy and disorder. It is based on numerical simulations using the three-dimensional Josephson junction array model. We support the results with an estimation of the internal energy and configurational entropy of the system. Our results give a unified picture of the behavior of the vortex lattice, covering from the very anysotropic Bi$_2$Sr$_2$CaCu$_2$O$_8$ to the less anisotropic YBa$_2$Cu$%_3$O$_7$, and from the first order melting occurring in clean samples to the continuous transitions observed in samples with defects.

Professor A was told they had been written at different times by a young researcher from the institution he was visiting. On the basis of what the author of the papers had said in the interviews commented above, Professor A was asked whether he felt the abstracts had been written differently, whether he thought the author was more mature and more at ease in one of the abstracts, and whether one of them "read" better than the other.

Interestingly, Professor A started his comments by focussing on "lower level issues" (Gibson 1993), i.e. spelling, details of grammar, etc., what Professor A himself termed during the interview as "hiccoughs":

"... well certainly Abstract 1 I don't think that I would be able to guess that it wasn't written by an English speaker... I don't see anything wrong with it... ... whereas Abstract 2 is... you see for instance there is a word anysotropic... that should be anisotropic... you see it should be an i instead of a y... he got it correct there... maybe it's just a slip... an understandable hiccough... but I wouldn't... also I think... when you say... *'Our results give a unified picture of the behaviour of the vortex lattice covering from the very anisotropic'*... that doesn't read quite right either... you don't say '*covering'* ... ... you could say *'covering examples ranging from'*... you wouldn't just say '*covering from'*... that's just a minor hiccough... it could be the other way round... whereas here [pointing to Abstract 1] I don't detect any... any hiccough at all..."

However, without my interrupting him, he then continued by discussing "higher level issues" (Gibson 1993) of discourse, having more to do with level of formality reflected in the use of passive versus active voice:

"I mean Abstract 1 is written in the... sort of professional passive sense... *'are discussed'* ... *'is discussed'* ... like that... this is the sort of jargon style as it were... this is more [pointing to Abstract 2] 'this-is-what-I-did' style... which is quite nice actually... I quite like that too... *'we propose something'* fine good for you... *'and this is what it is*

based on' … 'we support results' … we don't say 'a phase diagram is proposed' 'the results are supported'… and so on and so on ... (laugh)... that's what strikes me about this... there're in different modes as it were... well who's to say which is a better mode... I mean Abstract 1 is clearly in a more conventional impersonal mode... there is no doubt about that... but Abstract 2 is perfectly O.K.... ... and I would say that Abstract 2 reads in a very very nice friendly way... in a more chatty kind of informal way..."

Professor A was then told that Abstract J1 had been written first. He said that the scientist had done a perfect job with Abstract J1, but that although Abstract J2 had some minor flaws it was in fact more "fluid", and that the young scientist was speaking with his own voice. He finally commented that in the case of Ph.D. students writing up their theses, they certainly knew what the usual conventions were and when starting to publish.

"they might well want to be so strictly correct... and might not have the confidence... the self confidence... to write in a more personal voice".

This comment by Professor A could offer one explanation towards the highly conventional and impersonal tone of Abstract J1. He concluded that Abstract J2 flowed better and was in fact more fluent because, in his words,

"he [the author] is more relaxed... now you see he has already published four papers... he feels... you know... he's... what he's doing is O.K … ... he's speaking with his own voice more…".

3.3.3 Interviews with novice scientists

The two abstracts were also presented to nine Ph.D. students in physics from the Argentinian institution, who had either published or were in the process of publishing their first papers in English-language journals. As was pointed out in the introduction, papers in physics are mostly in English. Hence, undergraduate students of physics have to be able to read English very early on in their studies, and have to learn how to write in English during the course of their Ph.D. programme. Moreover, the Ph.D. students of the institution mentioned here are expected to have published a minimum of two or three articles in international journals by the time they get their doctoral degree.

The nine Ph.D. students were participants at a workshop on academic writing. The students were divided in three groups, and were given Abstract J1 and Abstract J2 as ASCII files (see above). They were asked, as in Professor A's case, whether they perceived differences in the way the two abstracts had been written, whether they thought the author was more mature and at ease in one of the abstracts, and whether one of them "read" better. Here again the purpose was to register participants' impressions, based on their perceptions as readers and novice writers of scientific papers.

Unlike Professor A, who had extensive experience as an editor, referee and supervisor of Ph.D. students, the participants did not attempt to approach the texts as editors, but rather just as readers. Their comments were more general and focussed on what they understood from the content of the abstracts, although they did offer comments about language features as well. Students in one group stressed that Abstract J2 was more attractive, more comprehensive and more powerful, with more far-reaching

conclusions than Abstract J1. They thought Abstract J1 probably dealt with a more specific and limited research topic. The second group said that Abstract J2 seemed to be more interactive and easier to read because it had no passive verbs. Students in the third group said that in Abstract J2 it was clear who proposed the model, whereas in Abstract J1 it was not. They said they preferred the "structure" of Abstract J2 because it had clear statements that were easier to read.

In sum, Professor A felt that the author was more conventional and more constrained in Abstract J1, whereas in Abstract J2 he seemed more independent and assured. In a similar way PhD students found Abstract J1 was of a more limited nature, whereas Abstract J2 was more powerful, with clear author presence. The author himself voiced the fact that he had felt more confident and his composing process had been easier when writing up Paper J2.

3.4 Method of text analysis

The previous section has presented the author's views on the articles, and preliminary impressions of informants based on the abstracts. This enables us to approach the linguistic analysis bearing in mind the context in which these texts were written.

Concerning the analysis per se, the focus throughout the present thesis is on Theme. We saw in Chapter 2 that Halliday associates Theme with what is given, known, and what the sentence is about (1994:37). Moreover, as Berry (1989, 1995) and Ravelli (1995) have shown, interactive meanings also tend to concentrate at the beginning of the sentence.

These more interactive meanings will be examined here and in the extended corpus because once physicists have obtained results that warrant publication, i.e. new information partly under the form of figures and equations, they then have to find the appropriate linguistic expressions to pass on these results to their research community. The more interactive types of meaning, which often tend to cluster in Theme, have then to be managed by scientists to convince their peers of the importance of their results.

The remainder of the sentence, which generally contains the new information, is called Rheme. Mention was made in Chapter 2 that in the corpus all the equations, which contain the new information that has to be passed on to the corresponding research community, are in Rheme position. Equations, and, in general, specialised new information are highly specific to a given discipline, and are thus extremely difficult to classify when doing linguistic analyses. The relatively more discipline-independent aspects of the research article can be studied by focussing on an analysis of Theme.

The next two subsections briefly recall how Theme is handled in the present pilot study and in the extended corpus, and are followed by another two that present taxonomies of Theme elements used only in the pilot analysis. New taxonomies will be developed and applied from Chapter 4 onwards.

3.4.1 Extension of Theme

We saw that within systemics there are very different positions regarding the extension of Theme. The analysis of the present study follows Enkvist's (1973) original proposition that Theme should include Subject. Chapter 2 looked in detail at similar

propositions taken up more recently by Davies (1988,1997), who also includes Subject as an obligatory element in Theme, and Berry (1989, 1995), who includes in Theme everything that precedes the verb of the main clause. Mauranen, in her study of academic texts in Finnish and in English, also states that " …it seems useful to take the entire preverbal part of the sentence into consideration when comparing thematic choices…" (1996:208). Because in the present corpus there are no elements between Subject and Verb, including either Subject or all preverbal elements in Theme is equivalent.

It was suggested that these extensions to Halliday's conception of Theme give it more pedagogic potential and make it closer to what we feel Theme should be. Moreover, the two potential functions for Theme identified by Davies as those of obligatory Topic, realised by Subject, and provision of optional Contextual Frame, realised by elements preceding Subject, will be the focus of the present analysis. The label Subject rather than the more problematic label Topic will be used in this thesis, mainly because there has been considerable discussion around what is actually the Topic of a sentence[9]. In order to give a clearer picture of essential thematic patterns without the interference of secondary organisation Theme is analysed in main clauses only. If subordinate or projecting clauses are put in front of the Subject of the main clause, these clauses are considered as performing an orienting function and are classified as Contextual Frames.

[9] See for instance Fries 1995:318.

3.4.2 Taxonomy of Theme components used in this study

For Halliday, when the Subject of a sentence is conflated with Theme it is treated as unmarked (i.e. it has no preceding elements). Both Davies (1988, 1997) and Gosden (1996) have discussed Subject functioning as unmarked Theme in academic texts. Moreover, on the basis of work initiated by Dane (1974) and taken up again in systemics by Fries (1983), Subject is discussed as a recurrent element in discourse.

We saw that optionally the Subject of a sentence can be preceded by a Contextual Frame whose function is to help "the development of Topic as the discourse proceeds" (Davies 1997:55). When this occurs, the Theme is said to be marked. An illustration of the framework offered by Davies was given in Figure 2, Chapter 2. An alternative illustration of unmarked and marked Theme from the present corpus[10] within the Davies framework is shown below with examples. Table 2 shows in particular how the optional element of Contextual Frame marks Theme. We saw above that in the present corpus Rhemes will not be analysed because they are much more specific to a given area of research. Here it is where all the equations have clustered, and where there is most of the "new" highly specialised message scientists want to pass on to their discourse community.

[10] In what follows all the examples in italics come from the present corpus.

Table 1 Unmarked Theme

The thermodynamical free energy F	*is obtained by minimizing with respect to ξ_c and ξ_{ab}: $F(T) = \min_{0 \chi \xi_{ab} \chi 1} \min_{0 \chi \xi_c \chi 1} \Phi(\xi_{ab}, \xi_c)$.*
SUBJECT UNMARKED THEME	RHEME

Table 2 Marked Theme

In this paper	*we*	*propose a qualitative H-T-η-D phase diagram of high-T_c materials that reproduces most of the available experimental results.*
CONTEXTUAL FRAME	SUBJECT	RHEME
MARKED THEME		

3.4.3 Discourse functions of Subject

Gosden (1996) has worked extensively on unmarked Theme - conflated with obligatory Subject - within the context of scientific writing, and his original taxonomy based on four domains was taken as such for the pilot analysis. The ordering of the four domains with their corresponding subdomains are presented from top to bottom reflecting the continuum from "personally visible" to "invisible" initially distinguished by Davies (1988) and developed by Gosden as a continuum from

"the Participant to the Real World Domain. Towards one end, it is typified by the increasingly overt presence of the writer as a visible participant in the research reporting process; towards the other, there is a greater focus on research-based, that is real-world physical and mental entities and activities." (1996:98)

1. The Participant Domain is realised by elements such as *We* and *Our approach*, where the author blatantly appears in the text.

2. The Discourse Domain is realised by elements such as *This point* and *Figure 4*. These elements focus on the text and its parts and on the discourse acts of reporting and discussing.

3. The Hypothesised & Objectivized Domain is realised by elements such as *a unified, consistent with experiments description of the problem, even at a qualitative level (is still lacking)* [sic][11] representing evaluative writer comment. This domain represents "a wealth of perhaps the most subtle means by which writer's comments on hypotheses and viewpoints can be realised" (Gosden 1996:101) and "may therefore be seen to represent the most discreetly interactional Theme" (ibid.). Furthermore, as Davies (1988) observes, the Hypothesised & Objectivized Domain enables authors to *treat* theories, hypotheses, models and categories as objective entities by putting them in Subject role, although they know such entities have a hypothetical status: "the hypotheses and categories are presented, together with evaluative comment, as objects with a greater than hypothetical status" (Davies 1988:194). An interesting example regarding this latter potential of Subjects in the Hypothesised & Objectivized Domain is the following from Paper J2 of the pilot study:

[11] Word order in this Subject from Paper J2 is awkward, but this is the way it appears in *Physical Review B* of the American Physical Society.

Table 3 Example of a Hypothesised & Objectivized Subject

The minimizing of F with respect to ξ_c *and* ξ_{ab}	*allows one to obtain the* $\xi_c(T)$ *and* $\xi_{ab}(T)$$ *functions, which in turn are used to detect the superconducting transitions*
SUBJECT UNMARKED THEME	RHEME

Here the author has chosen to put in Subject role a mathematical operation, in an attempt to give it greater objective status for other scientists. Instead of writing "I have minimized F with respect to ξ_c and ξ_{ab} so that I can obtain the new functions I need to detect superconducting transitions" he presents *The minimizing of F with respect to* ξ_c *and* ξ_{ab} as an objective entity. It looks as if it is not the researcher that minimizes F so that he can obtain $\xi_c(T)$ and $\xi_{ab}(T)$, but rather that it is the minimization of F – presented as an objective entity independent of the researcher - which "allows" the researcher to do other things, when it is actually the other way round.

4. The Real World Domain is realised by elements such as *Impurities* and *Dissipation*, which represent the researcher's object of study.

3.4.4 Discourse functions of Contextual Frame

Davies has analysed marked Theme and Contextual Frame and has observed that 'these framing elements are typically non-recurrent and as such signal changes, shifts or stages in the progression of the discourse' (1997:55). She adopts a categorisation which, in her words, 'allows for the inclusion, as examples of marked, and (multiple) theme, of elements which are not identified as such by Halliday, that is, the class of "minimal"

Adjuncts represented by conjunctive and modal Adjuncts and conjunctions and, in addition, *a small set of thematic Subjects which are seen to be marked in their semantic role* in that they do not identify participants, ..., but instead, appear to "frame" the message by specifying discourse goals or projecting evaluation' (1997:56, italics as in the original text).

The original Davies taxonomy of Discourse Functions for Contextual Frame is the following:

1. Logical Relations/Progression Contextual Frames (comparison, addition, contrast, reason, consequence, condition, concession, apposition/restriction). This type of Contextual Frame is subdivided for the purpose of the present study into Minimum and Maximum Logical Relations/Progression. Minimum Logical Relations/Progression are short conjunctive phrases such as *however, in addition, but*, etc. Maximum Logical Relations/Progression are whole clauses of condition, concession, etc., such as *Although this assumption cannot be fully justified a priori…*

2. Location Contextual Frames (e.g. *In Section III…, Within each layer…*)

3. Goal and Process Contextual Frames (e.g. *To make this estimation…, In order to be able to apply a current to calculate resistivities…*).

4. Evaluation Contextual Frames, where the author evaluates in expressions which come before the Subject of the main clause (e.g. *It is thus likely that*, *This indicates that, Note that in this case, Fortunately*).

A typical example of such frames in the present corpus is *It is thus likely that* (*the optimum value of η for the occurrence of the first order transition decreases with sample thickness)*, where *It is thus likely that* is a Contextual Frame which projects evaluation. Taylor Torsello offers an interesting account of this type of projection. She also suggests considering it as being of a highly interpersonal nature because it is 'a means through which speakers limit their own commitment to the message' (1996:156). Her views will be further discussed together with those of other systemicists when analysing the extended corpus of 30 articles.

It is this original Davies taxonomy which will be used for this pilot study.

3.5 Primary findings of the linguistic analysis

The present section presents the primary findings as they were obtained at the time when the pilot analysis was completed. The two texts were compared by means of the identification and categorisation of Theme elements presented above which uses the original Davies and Gosden taxonomies.

Interviews with the author indicated that although both papers presented results from the same superconductivity model using the same kind of numerical simulations, the last paper had been organised around one main result whereas the first paper had discussed several minor ones. This was confirmed by impressions from informants who

felt the author was initially more impersonal and less assured. The two texts were then analysed and compared with the following results.

3.5.1 Comparative analysis of Subject

Table 4 shows how Subject is distributed following the four domains distinguished by Gosden (1996). The percentages for Subject represent all instances of a particular Subject category divided by the total number of main Themes i.e. in the present analysis the total number of sentences. The Subjects are ordered from top to bottom, from more interactional Subjects with greater writer visibility to Subjects where the writer becomes less and less visible, that is from the Domain of Participant to Real World.

One main difference between the first and second paper was the variation in the distribution of Subjects in the Hypothesised & Objectivized and Real World Domains. In particular, the frequency of Subjects in the Hypothesised & Objectivized Domain was much greater in the second paper than in the first. We saw above that according to Davies the Hypothesised & Objectivized Domain allowed authors to *treat* theories, hypotheses, models and categories as objective entities by putting them in Subject role, although they knew such entities had a hypothetical status. By presenting elements of their work as subjects in this domain, authors gave them enhanced status within the scientific arena. This capacity of anchoring their work within an abstract world shared by the profession may help give authors, like the present physicist, a more 'expert' tone in their writing.

Another difference between the two texts was the degree of author participation reflected in the Subjects. Once the percentages corresponding to the Participant and Hypothesised & Objectivized Domains where the author is more visible are added together, in the first paper, Paper J1, the writer chooses to have some degree of presence in fewer than half of the Subjects, whereas in Paper J2, he is present in 77% of the Subjects. These two domains were added up together on the basis that authorial presence could be either overt, as in the Participant Domain, or covert, such as in the Hypothesised & Objectivized Domain, where authors were able to fashion certain types of persuasive Subjects that help convince readers of the importance and validity of their results.

Table 4 Distribution of Subject

SUBJECT	Paper J1	Paper J2
Participant	20%	24%
Discourse	5%	8%
Hypothesised & Objectivized	22%	53%
Real World	53%	15%
Subtotal Participant and Hypothesised & Objectivized	*42%*	*77%*
Subtotal without Hypothesised & Objectivized	*78%*	*47%*
TOTAL	100%	100%

When these results were obtained for the pilot study, they were also discussed in the light of a different cline, which I called at the time a cline of abstractness, where Participant and Real World were seen as being the less abstract choices, closely

followed by Discourse and culminating with Hypothesised & Objectivized, the most abstract choice of all. The three less abstract domains were summed up in the *Subtotal without Hypothesised & Objectivized*, with the result that in Paper J1 nearly 80% of the Subjects involved choices anchored in the Participant, Real World and Discourse Domains. Those choices were seen as being easier to make, in the sense that they involved putting into the Subject slot pre-established linguistic elements, such as the authorial *I – we* for Participant, *vortex, impurities, current, superconductor* for Real World, all of which are commonly used elements within the discourse community concerned, and *Section 1* and *Figure 2* for Discourse. In contrast, Hypothesised & Objectivized Subjects were seen as not commonly used elements, but rather as having been especially crafted by the author: compare for instance the difference between putting *superconductor* (Real World Domain) in Subject position, with putting *the superconducting coherence as deduced from simulations of the resistivity* (Hypothesised & Objectivized Domain) in Subject position. In Paper J2 more than half the choices were made in this last domain. It appeared that the author in Paper J2 was able to craft more precisely the kind of Subjects he needed to communicate his results and persuade his readers of their validity.

Finally, when comparing the Subjects chosen by the author in the two abstracts shown above, in Abstract 1 only one out of four Subjects belonged to the Participant Domain, which is the first Subject: *We (calculate ….)*. The other three are within the Real World Domain, i.e. *the voltage… and its dependence (are discussed) , the {\it ab-}plane resistivity (is well described)* … and *the response … to currents (is also discussed)*. In contrast, in Abstract 2 three out of four Subjects belonged to the Participant Domain: *We (propose …)*, *We (support …)*, *Our results (give …)*. The fourth

Subject is the pronoun *It* that refers back to *a phase diagram for the vortex structure of high temperature superconductors*, belonging to the more abstract Hypothesised & Objectivized Domain.

In sum, it was concluded at the time that the novice seemed more reluctant to appear in Paper J1, where Subjects tended to be more impersonal, less abstract and more commonly used terms than in Paper J2. In Paper J2 the analysis suggested a higher degree of authorial presence, as well as an increase in the use of abstract and complex Subjects. Such results went towards confirming first impressions by physicists when reading the abstracts.

3.5.2 Comparative analysis of Contextual Frame

Both papers had approximately 5,700 words and just over 300 Themes each, with marked Themes representing slightly less than 60% of the total Themes. The percentages shown in Table 5 represent all instances of a particular Contextual Frame category divided by the total number of Contextual Frames. Note that for Contextual Frames there is at the outset a choice: writers can choose whether to use them or not. Because they are optional elements in Theme, the results of the present comparative analysis have to be taken as being more tentative than in the case of Subjects that are obligatory elements.

Table 5 indicated some differences in the relative distribution of the four Contextual Frame categories distinguished by Davies.

Table 5 Distribution of Contextual Frames

CONTEXTUAL FRAMES	Paper J1	Paper J2
Minimum Logical Relations/Progression	44%	29%
Maximum Logical Relations/Progression	12%	13%
Location	19%	18%
Goal and Process	10%	11%
Evaluation	15%	29%
TOTAL	100%	100%

The main differences concerned Minimum Logical Relations/Progression (i.e. conjunctions) and Evaluation. For Minimum Logical Relations/Progression, the difference between Paper J1 (44%) and Paper J2 (29%) was mainly due to a prolific use in Paper J1 of the conjunction *and* by the novice researcher. In his later text, he reduced his use of conjunctions, in particular of *and*, and increased his use of Evaluation Contextual Frames.

However, as pointed out above, a comparative analysis of Contextual Frames is necessarily more tentative. In this respect it is interesting to note that when just looking at the abstracts, the Contextual Frame slot is only used in the first abstract, and not in the second. The three Real World Subjects of the first abstract are preceded by *In particular* (Minimum Logical Relations/Progression), *We find that* (Evaluation) and *To make connection with recent experiments* (Goal). In particular, the Evaluation Contextual Frame used in Abstract J1 would go against the trend indicated for the articles as a whole, with nearly double the amount of Evaluation Contextual Frame in Paper J2. One possible explanation is that as in the Abstract J2 the author chose to be

strongly present in three out of four Subjects, opting in addition for Evaluation Contextual Frames would have been excessive in this particular stretch of text.

3.6 Critique of the findings and a way forward

The pilot analysis intimated that with experience, the author tended to shift his choice of Subjects from the more obvious and commonly used terms of the Real World Domain to the more abstract and especially designed terms pertaining to the Hypothesised & Objectivized Domain. This trend was also noticeable in the abstracts, where only the first used Real World Subjects. During the interviews, the author said that his understanding of the physics involved had been much greater and that he had been able to organise more clearly Paper J2. This might explain why in Paper J2 he had been able to compose Hypothesised & Objectivized Subjects that expressed his meaning more precisely. In his words "I feel that I can put on paper what I'm thinking". Specialist informants concurred with the author's perceptions by saying the last abstract was more clearly organised and flowed better than the first.

The finding that with experience the author opted for more abstract and crafted Subjects was certainly interesting and needed to be tested with a wider corpus involving a greater number of researchers and a longer time span. However, as the pilot study was progressing, it started to become apparent that some of the criteria used for coding Subjects either in the Real World Domain or in the Hypothesised & Objectivized Domain was not sufficiently explicit, as will be discussed in the next chapter. The pilot study was helping in showing up these limitations, which needed to be overcome before proceeding with a more extended corpus.

Another implication of the pilot analysis was that as the author gained confidence he tended to select more interactive Subjects where his presence was either overtly manifested in the text in the Participant Domain, or covertly manifested in the more subtle Hypothesised & Objectivized Domain. This had also been suggested by specialist informants when reading only the abstracts. The expert physicist had contrasted the impersonal style in Abstract J1, where out of four Subjects, there was only one Participant, with the more personal style in Abstract J2, where, again out of four Subjects, there were three Participants and one Hypothesised & Objectivized Subject. The novices had also felt that Abstract J2 spoke more to the reader.

Finally, when the author had decided to mark his Subjects with Contextual Frames, he had initially opted for commonplace conjunctive and Circumstantial elements. As he gained experience he chose comparatively more Evaluation Contextual Frames, which simultaneously also made him more visible in the text. This was related at the time to the fact that the author was more confident about his findings, and had gained sufficient assurance to commit himself.

These last two findings, i.e. greater authorial presence both in Subject and in Contextual Frame, were also worthwhile to pursue and test on the basis of an extended corpus analysis, once coding problems were sorted out. Regarding Contextual Frames, it was felt that some of the characterisitics that started to emerge for Subjects, i.e. the fact that some were pre-established wordings commonly used within the discourse community concerned whereas others seemed to involve multiple strands of meanings, were also starting to appear on closer look for Contextual Frames. This observation was confirmed by talks with Margaret Berry after presentations made at two conferences in

July 1998 and July 2000. She said she saw interpersonal and experiential strands in the more complex Subjects, and even sometimes textual ones. She also felt that as the writer became more experienced, he became more proficient in managing all these different strands, and became better at interweaving them in Subject position. For Contextual Frame she advised me to identify some corresponding categories to my Subject ones. The object of the next chapter will focus precisely on setting up a new framework for coding Subject and Contextual Frame in an extended corpus.

PART TWO SETTING UP A NEW FRAMEWORK FOR CODING SUBJECT AND CONTEXTUAL FRAME

Chapter 4 Procedure: a brief look at how the Subject and Contextual Frame Categories have evolved in the present work

4.1 Introduction

The previous chapter presented the results of a pilot study which compared two articles by a single writer published in the same international journal. The analysis suggested that there were changes in both Subject and Contextual Frame as the writer gained experience. In the second article Subject choices appeared to be both less impersonal and more abstract, and Contextual Frames tended to be more evaluative.

However, during the pilot analysis certain coding problems were encountered, especially regarding the Real World and the Hypothesised & Objectivized Domains. Increasingly these problems appeared to result from the fact that Davies' and Gosden's purpose for setting up the categories and analysing Theme in texts was very different from the present one. They focussed on exploring the relationship between Theme choices and the generic characteristics of the research article. More precisely, and especially in the Gosden study (1996), the emphasis was on examining ways in which Theme choices and generic structure related to successful instances of scientific research communication.

The present study takes as its point of departure 'successful' texts, 'successful' in the sense that they are socially validated texts published in refereed international journals. The purpose is to explore whether there is any longitudinal evidence of change in Theme choices as writers gain experience in publishing results.

A more explicit set of coding criteria has to be found for the more problematic categories, in the hope of capturing relevant information on the development of the command shown by writers when composing text. The advantage of having done a pilot study is that a given research methodology can be tried out. In the present case the coding problems which showed up provide clues on how the coding criteria may be improved.

The present chapter presents the Subject and Contextual Frame categories arrived at when starting to probe further into the problematic categories. The quest for more explicit criteria will continue in the following chapters. The focus here is to introduce the new categories and explain how they were arrived at, but not to make an exhaustive presentation of the actual criteria for the categories. Complete criteria will be detailed and discussed in Chapter 5 for Subject and in Chapter 6 for Contextual Frame.

4.2 Difficulties with the original Subject categories

Participant and Discourse categories in the pilot study are those initially distinguished by Davies 1988 and taken up again by Gosden 1996. Both are relatively straightforward to code due to the fact that in the present corpus there are clear lexical clues which justify classification of Subjects into either category. Participant Subjects

focus on writers, and are worded as *we* in more than 90% of the cases. In the rest of the cases Participant Subjects are generally worded as *'our work'*, *'our results'*, etc., the lexical clue being the possessive pronoun *'our'*. Discourse Subjects focus on the terms writers use for naming the parts laid out in their research paper, and for the present corpus belong to a well defined lexical set mainly comprised by the words '*Figure* (x)', '*Table* (x)', '*Section* (x)' and by expressions such as '*(this) paper' '(the present) work'*.

Much more problematic to distinguish are the last two categories, the Real World and the Hypothesised and Objectivized Categories, both of which focus on phenomena the scientist is writing about. In my Masters dissertation and in pilot studies for the Ph.D. I originally used criteria laid out by Davies in 1988, and consequently used her terminology of Real World Subjects and Hypothesised and Objectivized Subjects. This terminology was adopted by Gosden (1996) who systematised Subjects into 'Domains'[12].

Both linguists focus on a cline of writer visibility for coding Subjects and have highlighted the differences involved in choosing one or the other class and hence to how committed and visible writers want to be in relation to their research. The 'Real World Subject' option is when writers choose to 'hide' behind the actual physical entities and the actual procedures executed on these entities. The 'Hypothesised and Objectivized Subject' option is when writers are able to treat theories, hypotheses, models and classes as objective entities by putting them in Subject role, although they know such entities have a hypothetical status.

However, when looking at my corpus, I sometimes found it extremely difficult to find criteria for distinguishing between the Real World and the Hypothesised and Objectivised categories set up by Davies. To mention just one of the difficulties encountered when coding Subjects, more often than not the object of research was per se a theory, a hypothesis or a model, which was subsequently being theorised and hypothesised upon, and then remodelled.

For instance, it seemed reasonable to classify *the mesh* as belonging to the Real World category and *the three-dimensional Josephson junction array model* as belonging to the Hypothesised and Objectivised category. But was it? I went back to talking to the author of the paper and other physicists. On the basis of these further interviews, it appeared that *the mesh* was just as much of an 'abstraction', as it were, as the *three-dimensional Josephson junction array model* - in fact it was part of constructing the model. Furthermore, most of the Subjects that appeared to be Real World ones were in fact models constructed by the authors. *The radial velocity profile calculated with the fine mesh* could be seen as belonging to the 'Real World' of the research concerned, although it is a model constructed by the researcher who wants to 'objectivise' it, and should then probably be coded as a Hypothesised and Objectivised entity. Subjects such as *the upwinding imbedded in the Lesaint-Raviart method* should then also be coded as belonging to the Hypothesised and Objectivised category precisely because 'the upwinding' - which could be seen as a Real World event - is in fact 'imbedded' in a method.

[12] From now on I use the term 'category' rather than the term 'domain' adopted by Gosden. In the present thesis there will be four Subject categories and four Contextual Frame categories. Contextual Frame

I felt I needed to revise my classification to have firmer criteria to replicate the classification for a wider corpus. Hence, more explicit criteria of use for defining these two Subject categories needed to be found. A systematic library search was undertaken in order to establish whether there had been further research relating to the development of a Subject taxonomy in academic texts. Peck MacDonald (1992) presents an interesting exploration of the differences in academic texts by means of a classification system based on Subject. In particular, she distinguishes between Phenomenal Subjects, which have to do with the researchers' object of study per se, and Epistemic Subjects, which have to do with the methods, conceptual tools and previous studies researchers bring to bear on that object of study. In other words, Epistemic Subject have to do with knowledge making type Subjects in the field of research concerned, whereas Phenomenal Subjects are the actual objects which are being studied. If we look at the examples above in the light of the Peck MacDonald taxonomy, *the mesh*, for instance, would be coded as a Phenomenal Subject. Now, in the case of the other two examples, *The radial velocity profile calculated with the fine mesh* and *The upwinding imbedded in the Lesaint-Raviart method*, when speaking to researchers involved in those fields, on the one hand they will say that both are their object of study, but that, in turn, both could also be regarded as having to do with knowledge making within their field of study.

One of the reasons for the coding difficulties encountered when using the Davies (1988) or the Peck MacDonald (1992) taxonomies is that many of the elements in the Real World or Phenomenal category and in the Hypothesised&Objectivised or Epistemic category share common characteristics. If we look at the writer visibility

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categories will then be refined and divided into subcategories.

cline, in all cases the writer is invisible, albeit perhaps in varying degrees. If we look at the cline of abstractedness, because of the characteristics of the present corpus, the elements written about are abstractions of the real, physical world which is being studied, albeit again perhaps in varying degrees. Finally, quite a few elements involve grammatical metaphor. Because grammatical metaphor can be found indistinctly in the RealWorld/ Phenomenal and the Hypothesised&Objectivised/ Epistemic categories, the following section discusses in greater detail the type of grammatical metaphor involved, and shows how some of Halliday´s insights can help find a way out of the taxonomic impasse encountered.

4.3 Halliday's two different kinds of grammatical metaphor - Type 1 referring/taxonomising metaphor and Type 2 expanding/reasoning metaphor

For Halliday 'If something is said to be metaphorical, it must be metaphorical by reference to something else. This is usually presented as a one-way relationship such that to some metaphorical meaning of a word there corresponds another, non-metaphorical meaning that is said to be "literal". Here, however, we are looking at metaphor not "from below", as variation in the meaning of a given expression, but rather "from above", as variation in the expression of a given meaning; the concept of "literal" is therefore not very appropriate, and we shall refer to the less metaphorical variant as "congruent".' (Halliday 1994:342)

Hence, whereas metaphor tout court involves a variation in the meaning of wordings, grammatical metaphor involves a modification in the wordings. The most common example Halliday gives is that of a wording, congruently expressed as a clause, which is then reworded in a nominalised form.

What is of particular relevance for the present quest for sound taxonomic criteria is Halliday's observation that there are in fact two different types of grammatical metaphor, a referring-type and an expanding-type. In particular, in Halliday's latest 1998 article on scientific discourse, he highlights again not only the importance of grammatical metaphor in scientific texts, but also the different roles both types have, because of the different things they enable writers to do:

'When a figure (congruently construed as a clause) is reworded, by grammatical metaphor, in a nominalised form, a considerable amount of energy is released in terms of the two semantic potentials mentioned above: the potential for referring and the potential for expanding - that is, for transforming the flux of experience into configurations of semiotic classes, and for building up such configurations into sequences of reasoned argument.' (Halliday 1998:197)

So the first type of grammatical metaphor - henceforth Type 1 metaphor - is the potential for referring, and has to do with the way scientists name their objects of study. This Type 1 metaphor has also been referred to by Martin as 'distillation':

'Perhaps the best metaphor for technical language is that of distillation. Technical language both *compacts* and *changes the nature* of every day words - just as a vat of whisky is both less voluminous and different in kind from the ingredients that went to make it up.' (Martin 1993: 172).

In the present corpus, Type 1 referring metaphor (that refers via heavily 'distilled' technical classes) has often to do with the actual things being studied, and sometimes

shares some common ground with what Peck MacDonald (1992) calls Phenomenal Subjects. Examples from the present corpus are technical terms such as *Fluorescence Photobleaching Recovery Spectroscopy* (or *FPRS* as it is referred to in the corresponding literature) that coins an experimental method currently used in optics, *Non-Newtonian Fluid Mechanics* (or *NNFM*), *High-ir Superconductors*, *the three-dimensional Josephson junction array model* (or *3D JJA model*) etc… .

The second type of grammatical metaphor distinguished by Halliday - henceforth Type 2 metaphor - is the potential for expanding used for building up the heavily 'distilled' technical classes into flows of argument. Type 2 expanding metaphor can also be viewed as knowledge making type Subjects, and could thus be viewed as sharing some common ground with the Hypothesised and Objectivised category distinguished by Davies (1988) and the Epistemic Subject category distinguished by Peck MacDonald (1992). Examples we have seen above are *the upwinding imbedded in the Lesaint-Raviart method* and *The radial velocity profile calculated with the fine mesh* where the scientist has nominalised his reasoning process.

What is interesting about Halliday's distinction between Type 1 referring/taxonomising metaphor and Type 2 expanding/reasoning metaphor is that Type 1 is already part of the enduring technical jargon of a given field of research, whilst Type 2 has had to be constructed for the needs of a particular instance of text, it is 'instantial'.

What is even more interesting, and explains the fuzziness experienced when using either the Davies or the Peck MacDonald taxonomy, is the continuum Halliday observes

between the two types of grammatical metaphor. With time, the instantial form of Type 2 expanding/reasoning metaphor may end up as a Type 1 referring/taxonomising metaphor, because it has become part of the language system: 'If we view the discourse of science in the longer term, we can observe the instantial *becoming* the systemic … instantial effects flow through into the system – because there is no disjunction between system and instance: what we call the 'system' of language is simply the potential that evolves over time. Thus any wording that is introduced discursively as a resource for reasoning *may* gradually become *distilled*; … … it becomes a new "thing".' (Halliday 1998: 221)

There often exist such continua in several categorisations, which of course explains in part the coding difficulties encountered not only with some Subjects, but as we shall see below also with Contextual Frames. In the present case of Subjects, Davies and Gosden view a continuum of writer visibility choices, going from Subjects where writers choose to be totally visible to ones where they progressively choose to become less and less visible. We also saw that Peck MacDonald perceived it more as a continuum of abstractness, going from more 'material' nouns to more abstract nouns. Halliday's continuum has to do with time. He distinguishes three different types of time where a wording initially created as a resource for nominalising reasoning processes may become part of the conventional language system of a given area of knowledge. The first is the time of unfolding of the text - logogenetic time, where what is initially presented as an instantial wording becomes part of the system as the text unfolds. The second is the time of evolution of the language - phylogenetic time, and the third the

time of growth and maturation of the user of the language - ontogenetic time (cf. Halliday 1998 222-223), the latter being the main concern of the present research.

Halliday indicates a way out of the taxonomic impasse by showing that in scientific writing, once the more easily identifiable Participant and Discourse Subjects are set aside, the Subjects that remain have many features in common: they are more specifically scientific wordings often - but not inevitably - involving either Type 1 referring/taxonomising metaphor or Type 2 expanding/reasoning metaphor. Differences have to do with dynamic views of language in general, and of writer development in the particular case of the present research.

The evolution of the categories was thus driven by the difficulties encountered when trying to apply previously existing taxonomies to the present corpus. I was able to take the first two categories of Participant and Discourse directly from the research initiated by Davies (1988) and developed by Gosden (1996). On the basis of the difficulties encountered in the last two more problematic categories and of further research the third category will now be called the Conventional category, i.e. commonly used wordings in the research field concerned often - but not inevitably - involving Type 1 referring/taxonomising metaphor. The fourth category will be called the Instantial category, i.e. wordings more especially created by the writer for a particular stretch of discourse often - but not inevitably - involving Type 2 expanding/reasoning metaphor. It is not the purpose of the present chapter to present detailed criteria for the categories, but rather to try and show how the criteria were arrived at for characterising

a ‘Conventional’ and an ‘Instantial’ category. This will be the purpose of the following section.

4.4 Distinguishing additional criteria

4.4.1 Type 1 and Type 2 metaphors

First of all acknowledging the possibility of a continuum for the last two categories of Subjects, inspired by the continuum made explicit by Halliday for Type 1 referring/taxonomising metaphor and for Type 2 expanding/reasoning metaphor, helped to understand the difficulties attached to their coding. However, more tangible criteria were still needed in order to be able to code Subjects as rigorously as possible. It started becoming evident that practically all the more Conventional Subjects tended to be shorter and more heavily nominalised via pre-modification than Instantial Subjects. The latter tended to be longer and more clause-like, mainly due to postmodification. In this respect it is important to stress that Halliday’s distinction of Type 1 referring/taxonomising metaphor and Type 2 expanding/reasoning metaphor was an enormous help towards finding clues for relevant criteria, but only partially constitutes a criterion for distinguishing between Conventional and Instantial Subjects. It is only partial because the latter type of Subject can for instance include clauses such as in the case of *the angle above which the points begin to follow the intrinsic anisotropy of the material* or be a clause of a non-finite nature such as *The failure in achieving a satisfactory representation of the selected data*.

4.4.2 Modification in nominal groups

On the basis of the coding difficulties described above and the fact that a useful distinction was needed in order to explain what was perceived as happening in the texts, a final step was having numerous discussions with my supervisor and giving presentations at seminars and conferences. What started to emerge was that many of the problematic Subjects, which had started off as 'Hypothesised and Objectivized' and had then been coded as having 'Epistemic' characteristics, were in fact heavily modified in particular ways. The advantage of pinning down the coding to certain types of modification is that in doubtful cases additional and more tangible criteria can be used. Additional grammatical criteria emerged little by little from discussions with Davies (2000), who encouraged me to have another look at Sinclair 1991 and at grammars such as Cobuild (1990) and Downing and Locke (1995), which led me to looking in more detail at nominal groups and modification therein.

Functional and discourse views on the structure of nominal groups see nominal groups as being based on a headword which can be pre-modified and postmodified by different linguistic elements. Halliday (1985, 1994: Chapter 6), when looking at the experiential structure of the nominal group, identifies the functions of Deictic, Numerative, Epithet, Classifier and Thing[13], Thing being realised by the headword. Elements which follow the Thing have the function of Qualifier. Sinclair (1991: Chapter 6), referring to the classes of words that typically realise these functions, describes the structure of nominal groups as being based on a headword which is a noun (i.e. in functional terms, Thing). In front of the noun come determiners, numerals, adjectives, etc. (i.e. in functional terms, Deictic, Numerative, Epithet etc.) that extend its meaning

in different ways. After the noun come prepositional phrases and relative clauses (i.e. in functional terms, Qualifiers) that add further strands of meaning.

4.4.3 'Of-type' nominal groups

Sinclair discusses in greater detail 'Of-type' nominal groups, which are by far the most common in corpora in general, and my corpus is no exception. When discussing prepositions in general Sinclair points out that their main role is to introduce prepositional phrases which function as Adjuncts. However, he suggests that this is not the main function of '*of*', the most common preposition of all, which is mainly used in association with other nouns to produce new meanings, either by introducing a second noun as a potential headword, or by forming double-headed nominal groups. For instance, when new meanings are formed on the basis of double-headed nominal groups, neither noun seems to be more significant or dominant, and to express these new meanings the *'of'* structure tends to require both nouns.

In the present corpus typical examples involving prepositions such as *in* which introduce prepositional phrases are:

… in ref. [14] …

… in Figure 1 …

… in this model …

whereas typical cases of *of* combining with other nouns are:

… Equations of Motion …

… Mechanics of Fluids …

[13] Halliday uses capital letters for these functional labels.

Sinclair goes as far as saying that it might perhaps be better not to consider *of* as a preposition at all, because its main role of combining with other nouns to produce new meanings is so different from that of other prepositions. I shall not carry further Sinclair's discussion, as it would take us too far from the analysis, but rather make use of his insights for added judgement in discerning between Conventional Phenomena and Instantial Phenomena categories. Typically, all the examples presented above will be classified as belonging to the Conventional Category. In particular, expressions such as *Equations of Motion* and *Mechanics of Fluids* can now safely be considered as conventional wordings, although when they were initially coined, probably around the Eighteenth Century, they were highly innovative ones. These two expressions are actually good examples of what were originally Type 2 expanding/reasoning metaphors becoming Type 1 referring/taxonomising metaphors. In the previous section we discussed Halliday´s views of the long-term evolution of the discourse of science, and the way in which some of the wordings that had originally been introduced for reasoning had become part of the commonly used terms within a given research field.

In contrast, wordings such as *In spite of the lack of a true critical temperature in a thermally activated model,* will be coded as belonging to the Instantial category because they are wordings of the expanding/reasoning kind which have been especially created for a given stretch of discourse.

4.4.4 Differing grades of creativity

Hence the distinction of the two problematic categories has not do with whether Subjects are ‘Real World’ or ‘Hypothesised and Objectivised’, or whether they are Phenomenal or Epistemic. In fact, the Subjects in my corpus have always got to do with

abstractness and with the phenomena being discussed. The point of interest for the present research is that they may involve different grades of creativity on the part of the writer. Writers can base their Subject choices on the readily accessible wordings conventionally used in their field. On the other hand writers may want to create tailored wordings that precisely fit into a particular stretch of discourse to convey meanings more precisely. They are in a position to do so once they have deeply reflected upon and assimilated the substance with which they are working, and have made the material their own, as it were. Hence my Conventional and Instantial labels to differentiate these last two categories. The idea of a Conventional and an Instantial category was arrived at as a consequence of the difficulties encountered when going to the corpus and trying to apply previously existing taxonomies. The next section shows that similar difficulties arose when trying to discern changes in the use of Contextual Frame as writers gain experience, and that the path followed to find a way out of the Subject impasse was also useful for finding new ways of looking at Contextual Frame.

4.5 Transferring the insights gained through the analysis of Subject to Contextual Frame

The initial coding of Contextual Frames in the pilot study was based on the four main categories distinguished by Davies 1997, i.e. Logical Relations/Progression, Location, Goal & Process and Evaluation Contextual Frames. In fact, Davies' classification is much more delicate, with several subcategories for each one of the four categories. In Location she distinguished the subcategories of Time, Place, Discourse, Discourse Data, Social Process (e.g. *On that occasion*) and Theory, and in Logical

Relations/Progression the ones of Comparison, Addition, Contrast, Reason, Consequence, Condition, Concession, and Apposition/Restriction. For Goal and Process there are another five subcategories, Purpose, Means, Role/Behalf, Quality/Manner and Discourse Goal (e.g. *The aim of my study*). Finally, in Evaluation Davies identifies Objectivised Viewpoint (e.g. *The inadequacy of this*), and three other categories which concern existential-*There* constructions, anticipatory-*It* Themes such as *It [is obvious that]* and modal Adjuncts.

However, it should be made clear at this point that Davies' classification was set up with a different purpose from that of the present study. Her purpose was to analyse Theme in order to identify distinctive features of text-types[14], texts and genres. More specifically, in her 1997 paper Davies explores 'the potential of the analysis of marked Theme as a means of differentiating amongst Interactive and Topical units of *Texts* as a constituent of *Genres* and as a means of signalling the progression of a text.' (Davies 1997:53, italics as in the original). My purpose, on the other hand, is to analyse Theme in order to discern signs of writer development. The present research analyses similar texts - all research articles in physics - belonging to the same genre of English in research settings, and the differences I want to investigate are the ones due to increasing writer expertise. This is why it became necessary to reconsider the classification to make it more effective in identifying traces of writer development, this time in the use of Contextual Frame.

[14] Davies defines text-types as 'constituent units of *Text* located at a level above that of *Rhetorical Pattern*' (Davies 1997:50, italics as in the original) and located at a level below that of Text. Text is seen by Davies as being a coherent piece of writing, with characteristic structure and texture in the sense of Hasan (1976, 1989), with a given author or authors and clear boundaries. Units or sections of such Texts would be Text-Types. Examples of Texts given by Davies would be books, letters, and also articles within journals. A Text-Type would for instance be the introduction of an article.

4.5.1 First stage of the new Contextual Frame classification: reconsidering the four original categories

In a first stage I examined the taxonomy used in the pilot study in the light of the Conventional/Instantial distinction I had found so useful for Subject. However, it is important to note that one of the possible ingredients allowing such a distinction for Subject, i.e. the possibility of Type 1 referring/taxonomising metaphor in Conventional Subjects and Type 2 expanding/reasoning grammatical metaphor for Instantial Subjects is not applicable for Contextual Frames. This is because Subjects are characteristically noun groups, whereas Contextual Frames are not. In scientific writing noun groups have often originated from clauses. Rewording them in a nominalised form gives them the potential to refer and to expand. For Contextual Frame, rewording clauses in a nominalised form is possible only for Circumstantials. Nevertheless there were other more important means of establishing the Conventional and Instantial categories, the principal one being that in one case the writer employs commonly used terms, and in the other the writer composes special elements for a given stretch of discourse.

Interestingly, I had already previously distinguished within Logical Relation/Progression what I had termed at the time of the pilot study Minimum Logical Relations/Progression and Maximum Logical Relations/Progression. This distinction had been an embryonic attempt at seeing things in a Conventional or Instantial light, in the sense that Minimum Logical Relations/Progression are standard elements which generally have to be placed in Theme position (Halliday 1994: 48-49), whereas Maximum Logical Relations/Progression are elements which are specially fashioned for a given stretch of discourse and could have been positioned in Rheme.

The next two categories of the pilot study were Location and Goal and Process. I looked in detail at the wordings used to express these types of meaning and found the following: Contextual Frames coded under Location were non postmodified Circumstantials. Here are ten examples taken from the two papers: - *During the last few years, - In this work, - In the next section, - In Fig. 1, - At this temperature, - In this model, - In a random walk analysis, - In the magnetic coupling case, - In an intermediate situation, - Within each layer, - At low fields*.

In contrast, Contextual Frames coded under Goal and Process typically include non-finite clauses and postmodified Circumstantials, but very few Circumstantials which have not been postmodified. Here are examples of non-finite clauses, both of the *to*-infinitive form and of the *ing* form, which illustrate the much broader range of meanings coded as belonging to Goal and Process: - *To make connection with recent experiments, - In order to make this point clearer, - To calculate the {\it ab} plane resistivity, - In order to effectively find the phases $\varphi $ as a function of time, - In addition, using the same model, - Having in mind these three qualitatively different behaviors, - Having discussed the $\eta $-$D$ phase diagram for a fixed magnetic field H%, - Connecting nearest Neighbors*. Examples of postmodified Circumstantials coded as belonging to Goal and Process are, for instance, - *For a system of L_c completely decoupled planes, - For this scheme to be valid*.

Here again examples indicate differences in the type of wordings used in Contextual Frame position. In the Location category wordings are generally simpler and of a more conventional nature than in the Goal and Process category. In this latter category meanings are generally realised by postmodified Circumstantials and non-finite clauses of a more complex and instantial nature.

Finally, when looking at Evaluation and the wordings therein, differences can also be discerned along the Conventional/Instantial lines. There is simple evaluation via modal Adjuncts such as - *Typically* and - *In general*, evaluation via projecting clauses such as - *We show that, - We checked that, - This indicates that* and - *Note that*. By contrast, evaluation may be embedded in clauses holding multiple meanings such as - *However, having in mind that we are interested in the case where the model is an adequate representation of a continuous superconductor …* and - *Although we do not show all the results, we observed that when the resistivity has a jump ….*

In sum, what I was able to discern once I went back to the original four Contextual Frame categories I had used for the pilot study was the following:

- The Logical Relation/Progression Category is comprised of:

Minimum Logical Relation Contextual Frames and Maximum Clause-type Logical Relation Contextual Frames.

Minimum Logical Relation Contextual Frames map on to the Textual elements in Theme distinguished by Halliday.

Maximum Clause-type Logical Relation Contextual Frames map on to the Hypotactic clause Theme distinguished by Halliday (1985:57, 1994:56).

- The Location Category is comprised of Circumstantials of Location practically all of which are not postmodified.

- The Goal and Process Category is a very broad class indeed, comprised of Circumstantials, either postmodified or not, and different types of non-finite clauses.

- The Evaluation Category is comprised of:

Simple Evaluation Contextual Frames, Projection-type Evaluation Contextual Frames and Evaluation embedded in clauses.

Simple Evaluation Contextual Frames map on to modal Adjuncts, i.e. they represent Interpersonal elements in multiple Themes discussed by Halliday (1985, 1994:54).

Projection-type Evaluation Contextual Frames, as indicated by their name, map onto projecting clauses which are seen by Taylor-Torsello (1996) as having both a logical and an interpersonal flavour.

Evaluation embedded in clauses map on to Hypotactic clause Themes with an added interpersonal strand.

Examination of Subject choices in the light of the Conventional/ Instantial distinction was potentially an indicator of writer development. On the basis of the observations made above that some Contextual Frames also showed signs of being much more elaborate than others, it was decided to rearrange the four categories bearing in mind again the Conventional/ Instantial dichotomy.

The original Location Category was coded under a new Conventional Category for Contextual Frames, together with other Circumstantials without postmodification, which may include Type 1 referring/taxonomising grammatical metaphor.

Heavily crafted Contextual Frames of a clausal type or consisting of postmodified Circumstantials that may include Type 2 expanding/reasoning metaphor are now coded under the Instantial category.

Contextual Frames entailing an added interpersonal strand are coded under what will be called from now on the Expressive Category. In the present corpus it covers all expressions containing an interpersonal strand such as - *In Sec. IV we indicate that …* - *In some other cases we will obtain that …* - *If we were able to increase the thickness up to infinite and measure the resistivity of the sample.*

Contextual Frames worded as conjunctive Adjuncts, modal Adjuncts or coordinating conjunctions, all of which tend to be, or even sometimes have to be, thematic (Halliday 1985, 1994:48), are now coded as belonging to the 'Typical' Category. In particular, it was felt that modal Adjuncts, whose typical wordings in the present corpus were *In general* and *In particular,* belonged more to the 'Typical' Category than to the 'Expressive' one. The four new categories and the way they are realised are shown in Table 6.

Table 6 The four categories and their realisations

Typical Contextual Frames	Conventional Contextual Frames	Instantial Contextual Frames	Expressive Contextual Frames
realised by Conjunctions Conjunctive and Modal Adjuncts	realised by Circumstantials without postmodification	prototypically realised by Clauses and postmodified Circumstantials	prototypically realised by Projecting Clauses (optionally embedded)

The categories have been ordered from left to right, going from the more characteristic and conventional to the more crafted and expressive, i.e. from the Typical to the Conventional, the Instantial and the Expressive Categories. Each one of these categories is either realised or prototypically realised by different elements. When I use the word 'Realisation', it means that for instance Typical Contextual Frames are conjunctive and modal Adjuncts. When I use the words 'Prototypical realisation', it means that for instance Expressive Contextual Frames are generally realised, or characterised, by projecting clauses, but that these are not necessarily the only possible wordings. In this respect it is particularly interesting to note that as we move away from Typical and Conventional Contextual Frames and towards the more fashioned Instantial and Expressive Contextual Frames, there are no more 'Realisations' tout court but rather 'Prototypical realisations'.

4.5.2 Second stage of the new Contextual Frame classification: distinguishing subcategories within the four new categories

However, as the corpus analysis was advancing, it was felt necessary to distinguish subcategories within the four broad categories. There were two main reasons for this: one was that Contextual Frame elements are of a much more varied nature than Subject elements. Subjects are overwhelmingly noun groups, whereas Contextual Frame elements can be Adjuncts, noun groups, prepositional groups, non-finite clauses, finite clauses, etc. The other reason, possibly a consequence of the previous one, was that the pilot analysis showed virtually no change in the evolution of Conventional and Instantial Contextual Frames as the researcher gained experience. This finding had to be checked to see if it was not due to too many different elements being grouped together within a category and having contrasting trends as time went by. If some elements within a category increased, whilst others decreased, these contrasting trends would be neutralised and, when looked at together, would show no change.

Hence, it was felt necessary to refine the categories. The solution that was adopted was making the grammatical criteria upon which the previous classification had been based more delicate. This was done over a period of time. The first step was to distinguish two subcategories for each class, as shown in Table 7.

Table 7 Two subcategories per category

Typical Contextual Frames		Conventional Contextual Frames		Instantial Contextual Frames		Expressive Contextual Frames	
1	2	3	4	5	6	7	8
realised by Conj. and Conjunctive Adjuncts	realised by Modal Adjuncts	realised by Circum. of Location (Theory, Discourse and Time,)	realised by other Circum. not post-modified	prototyp. realised by: Finite clauses mainly of Condition	prototyp. realised by: Non-Finite Clauses mainly of Manner/ Means & Cause/ Purpose	prototyp. realised by: Clauses with embedded evaluation	prototyp. realised by: Projecting Clauses

However, as the analysis based on the classification presented above proceeded I very soon saw that I was coding many Circumstantials, especially of Cause and Condition, as belonging to the Instantial category, while my subcategories only referred to clauses as prototypical realisations of this category. Accordingly, an extra Instantial subcategory was added and classified under Column 6 'prototypically realised by Circumstantials of Cause and Condition or other Postmodified Circumstantials'. Hence, under the general heading of 'Instantial Contextual Frames' there were now three different subcategories briefly presented in the subheadings of Columns 5 to 7 below.

Table 8 Categorisation with three Instantial subcategories

Typical Contextual Frames		Conventional Contextual Frames		Instantial Contextual Frames			Expressive Contextual Frames	
1	2	3	4	5	6	7	8	9
realised by Conj. and Conj. Adjuncts	realised by Modal Adjuncts	realised by Circum. of Location (Theory, Discourse and Time,) not post-modified	realised by other Circum. not post-modified	prototyp. realised by: Circum. of Cause and Condition or other post-modified Circum.	prototyp. realised by: Finite Clauses mainly of Cause/ Reason& Result and Condition	prototyp. realised by: Non-finite Clauses mainly of Manner/ Means and Cause/ Purpose	prototyp. realised by Clauses with embedded evaluation	prototyp. realised by Projecting Clauses

However, as I was progressing in the coding of Contextual Frames with the nine subcategories identified above, I noticed the newly added Instantial subcategory in

column 5 remained unsatisfactory because it still contained Contextual Frames which were very different. This subcategory, whose prototypical realisation was characterised as being 'Circumstantials of Cause and Condition or other Postmodified Circumstantials' was thus further divided in 'Postmodified Circumstantials of Cause and Condition' (column 5 in Table 9 below) and 'Other Postmodified Circumstantials' (column 6 in Table 9 below), so that now the general category of Instantial Contextual Frames included four different subcategories.

Table 9 Categorisation with four Instantial subcategories

Typical		Conventional		Instantial				Expressive	
1	2	3	4	5	6	7	8	9	10
realised by Conj. and Conj. Adjuncts	realised by Modal Adjuncts	realised by Circum. of Location (Theory, Discourse and Time,) not post-modified	realised by other Circum. not post-modified	realised by post-modified Circum. of Cause and Condition	prototyp. realised by other post-modified Circum.	prototyp. realised by Finite Clauses mainly of Cause/ Reason& Result and Condition	prototyp. realised by Non-Finite Clauses mainly of Manner/ Means & Cause/ Purpose	prototyp. realised by Clauses with embedded evaluation	prototyp. realised by Projecting Clauses

As the analysis was progressing still further, it was decided to add another subcategory concerning more specifically meanings of Cause and Condition, this time under the Conventional heading. This was done taking into consideration the importance of these types of meanings in science research papers, and the diverse way in which they are realised in Contextual Frame position. Cause and Condition Contextual Frames such as *and for this reason*, *For condition n (ii)*, *Because of the prefactor (t - to)** belong to the Conventional Category. Consequently, Subcategory 4 of the Conventional Category which grouped all Circumstantials without postmodification except Location was divided into two subcategories as shown in Table 10 below. Under the Conventional heading we now have three subcategories (Columns 3, 4 and 5):

Table 10 Final categorisation with eleven subcategories

Typical		Conventional			Instantial				Expressive	
1	2	3	4	5	6	7	8	9	10	11
realised by Conj. and Conj. Adjuncts	realised by Modal Adjuncts	realised by Circum. of Location (Theory, Disc. and Time,) not post-modified	Realised by Circum. of Cause and Cond. not post-modified	Realised by Other Circum. mainly of Matter and Angle not post-modified	prototyp realised by post-modified Circum. of Cause and Cond.	prototyp realised by other post-modified Circum.	prototyp realised by Finite Clauses mainly of Cause/ Reason &Result and Cond.	prototyp realised by Non-Finite Clauses mainly of Manner/ Means and Cause/ Purpose	prototyp realised by Clauses with embedded evaluation	prototyp realised by Projecting Clauses

Now that the subcategories within the Conventional Category have been made more delicate by using more detailed criteria it becomes noticeable, for instance, that preferred wordings for Conditional and Cause-type meanings are non-finite and finite clauses of the Instantial Category. Wordings involving Circumstantials, either postmodified or not, are not as frequent. It is also interesting to note that Conventional wordings such as *For condition n (ii)* could be argued to have two 'Circumstantial flavours' so to speak: Matter and Condition. This will be discussed further in Chapter 6 where criteria for Contextual Frame are discussed at length.

Going back to the preferred wordings for Conditional and Cause-type meanings being non-finite and finite clauses, Halliday remarked on these preferred wordings in the following way:

'Since the semantic relations involved in contingency[15] are typically relations between processes, they are often realised clausally (cf. reason and purpose above[16]);

[15] Throughout this work I consistently use the label 'Condition' as a general label rather than that of 'Contingency'. At first Halliday uses 'Contingency' as a general label under which he distinguishes

the most usual conjunctions are *if*, *although*, *unless*. When they are construed as circumstances, with a prepositional phrase, the noun is typically the name of an event, like *typhoon*, or a nominalised process as in *in spite of popular objections* (cf. *although people objected*).' (Halliday 1994: 156, italics and parentheses as in the original) In contrast, the analysis of the present corpus suggests that preferred wordings for Location, and Matter and Angle are within the Conventional Category.

The table below presents what will be the final and most delicate classification in the present work, based on eleven subcategories. Chapter 9 on results for the Contextual Frame analysis discusses first results obtained when undertaking an analysis based on the four categories, and then discusses results obtained when doing an analysis based on the eleven subcategories.

4.5.3 Adding metafunctional labels

As I was using the taxonomy presented above, there appeared the question of how categories related to the metafunctions, and whether these should appear in the following way:

'Condition', 'Concession' and 'Default' (Halliday 1994:152-158). However, he then abandons the general label 'Contingency' when he goes on to discuss different types of expansion, and switches to the general label of 'Condition' under which he distinguishes 'Positive', 'Negative' and 'Concessive' (Halliday 1994: 328). It is this latter general label of 'Condition' which is adopted here.

[16] Here Halliday refers to two main subcategories of Cause.

Table 11 Final categorisation with metafunctional labels

Mainly Textual		Mainly Experiential							Mainly Interpersonal	
with an added Logical flavour throughout										
Typical		Conventional			Instantial				Expressive	
1	2	3	4	5	6	7	8	9	10	11
realised by Conj. and Conj. Adjuncts	realised by Modal Adjuncts	realised by Circum. of Location (Theory, Disc. and Time,) not post-modified	Realised by Circum. of Cause and Cond. not post-modified	Realised by Other Circum. mainly of Matter and Angle not post-modified	prototyp realised by post-modified Circum. of Cause and Cond.	prototyp realised by other post-modified Circum.	prototyp realised by Finite Clauses mainly of Cause/ Reason &Result and Cond.	prototyp realised by Non-Finite Clauses mainly of Manner/ Means and Cause/ Purpose	prototyp realised by Clauses with embedded evaluation	prototyp realised by Projecting Clauses

This was decided against on the one hand because metafunctional labels did not really add vital information to further clarify the categories, and, on the other, because there are problems with metafunctional labels especially with the Textual and the Logical ones. Regarding these problems, Berry (1996 - see footnote 2), for instance, has pointed out Halliday uses 'textual' in two different senses. In a broad sense he defines it as 'creating relevance to context' (IFG1994: 36). Halliday (1978: 145) also says that textual meaning 'enables' other types of meaning, a view which has been taken up again by various systemicists including Mathiessen (1995). Likewise, Berry assumes that textual meaning enables, through culminative positioning, the giving of prominence to the other types of meaning, i.e. interpersonal and ideational meanings.

However, Berry then remarks that Halliday also uses the term in a narrow sense when he classifies particular types of Theme as 'Textual Theme', (IFG 1985: 54; IFG 1994: 53-4). Berry points out that items such as *however* and *in addition*, which are examples of what Halliday calls Textual Themes, do not seem to be enabling the prioritisation of interpersonal or experiential meanings, but rather seem to have a type of

meaning of their own, which in turn would need to be enabled by being placed in certain positions. Berry then suggests that this type of meaning appears to be logical meaning. She argues her case by drawing attention to the fact that Halliday defines logical meaning as 'constructing logical relations' (IFG 1994: 36) and as being realised by 'iterative structures'. When Halliday discusses in more detail logical relations, Berry says they appear to be realised by some of the items earlier said to be realising Textual Themes, which then makes her ask the following question: 'Is it possible that "Textual Themes" are not actually either textual or Themes, but instead have more in common with Logical meaning?' (Berry 1996: 38 - see footnote 2) Berry also suggests giving a new name to Logical meaning and call it Transitional meaning.

Another interesting view of the problematic Logical metafunction is the one presented by Taylor-Torsello (1996). She suggests that the Logical metafunction could be considered 'as an added function available for combination with each of the other three metafunctions, and related equally to each of these, as well as to field, tenor and mode of the context of situation.' (1996: 151) Taylor-Torsello believes that some problematic areas of grammar could be advantageously reconsidered when having in mind the fact that the Logical metafunction is even more multifunctional than the other metafunctions (see for instance1996:155). She specifically suggests reconsidering, in this light, areas such as Circumstantials, projected clauses, existential-*There* and anticipatory-*It* constructions, all of which are prominently in Contextual Frame position.

Detailed work on clause-initial disjuncts[17] by Thompson and Zhou (2000) gives additional reasons for the need to adopt a more multifunctional approach. Even when considering just one word, such as *unfortunately* in sentence-initial position, they see it as telling what the writer thinks, speaking to the reader and moving the argument forward. They thus claim that "It is impossible to separate the Interpersonal from the Logical" (Thompson and Zhou 2000:122). They also query the distinction of roles made between conjunctions such as *and*, which are seen as playing a part in the textual metafunction, and disjuncts or modal Adjuncts such as *unfortunately*, which are seen as playing a part in the interpersonal metafunction. They suggest that conjuncts and disjuncts should not be ascribed to a single metafunction. Furthermore, they see cohesion as belonging simultaneously to the textual and to the interpersonal.

In view of the ongoing discussion concerning ways of considering metafunctions, and the trail of unanswered questions that have been raised above, metafunctional labels as such will be left aside for the moment. However, it could be of help to keep in mind the different metafunctional flavours connected with each of the four categories.

4.5.4 Last observations on the final classification

As noted above, it is this last taxonomy which will be used in the analysis of Contextual Frames in the 30 articles. The subcategories have helped me to understand the composition of the main categories, and to observe in greater detail the different

[17] Thompson and Zhou adopt the label 'disjunct' used for instance by Downing and Locke (1992) for elements such as *unfortunately* (1992:15) or *in fact* (1992: 63). Halliday would label *unfortunately* as a modal Adjunct of desirability, and *in fact* as a conjunctive Adjunct, verificative (1994:49). In the present thesis these elements have been considered as functioning as Adjuncts following Halliday (1985, 1994).

elements within each category. The 'Typical' Contextual Frame category is realised by conjunctions and Adjuncts, the 'Conventional' Contextual Frame category by non postmodified Circumstantials with one main strand of experiential meaning, even though there are cases of fuzzy boundaries. The 'Instantial' category is composed of Contextual Frames that are much more 'multistranded' in the type of experiential meanings they express than Contextual Frames belonging to the Conventional Category, so rather than having fuzzy boundaries we would have clearly overlapping and intertwined ones. Moreover, the 'Instantial' Contextual Frame category has diverse prototypical realisations, going from postmodified Circumstantials to non-finite clauses to whole finite clauses.

Finally, the 'Expressive' Contextual Frame category has two subcategories, of which Subcategory 10 has the Instantial characteristic of being realised by clauses with multiple strands of meanings. Subcategory 11, realised by projecting clauses, is perhaps more typical and more conventional[18] than Subcategory 10. It is typical in the sense that, as Halliday (1994) put it for modal Adjuncts, if writers choose to include in a clause some element giving their personal view "it is natural to make this the point of departure" (Halliday 1994:49-50). Projecting clauses are illustrative of such elements. This makes it possible to extend Halliday's observation for modal Adjuncts to projecting clauses.

Projecting clauses also have some conventional characteristics because wordings such as *It is interesting that*, *Note that*, etc… do not have multiple strands of meanings, but rather one main strand of interpersonal meaning whose function is to give the writer's angle on a given point. These wordings are made in a rather conventional way,

i.e. in a way the novice writers of research articles can easily pick up from previous readings.

In the next section below I compare the results of the original coding scheme with the new one, in order to gain added insights into the procedure that led to changing the coding scheme.

4.6 The pilot study: comparison of results using the original coding scheme and the new coding scheme

4.6.1 Comparison of results for Subject

As discussed above, in the pilot study it was found increasingly hard to pin down the difference between certain 'Real World' and 'Hypothesised and Objectivized' Subjects. After many months spent in building up the new taxonomy, I went back again to my original pilot study. I did my own double checking, with the analysis using the new taxonomy being done twice and then checked by my supervisor. First, an analysis was done on hard copies of the analysed texts, which were then put aside for a few days. Second, the same analysis was undertaken directly on the computer files. This double checking procedure of analysing first a hard copy and then an electronic one was also followed for the corpus of 30 articles. As expected, there was no difference for the more circumscribed Participant and Discourse categories. For the Conventional and Instantial categories the differences were small and concerned mainly Subjects containing deixis and others that turned out to be Anaphoric or Cataphoric-noun type Subjects. These Subjects were especially problematic and were generally coded as Instantial according to the context in which they appeared.

[18] I have not used capital letter for typical and conventional on purpose, because I am using these terms in a general way and within a different context of meanings, interpersonal ones. Up to now they have been used as labels for classes of (mainly) experiential Contextual Frames.

Francis (1986) points out that the function of an Anaphoric noun is to label preceding stretches of discourse which are thus integrated in the general flow of argument and are typically heavily context dependent. By choosing certain types of noun, such as for instance *this ambiguity*, the writer is not only labelling a preceding stretch of discourse, but is also indicating to the reader that s/he considers what has been discussed before as ambiguous. In Francis' words 'In interactive terms, then, A-nouns are highly informative, contributing to provide the reader with a conceptual framework for understanding the writer's plan.' (1986:39). Doubtful cases of course remain with anaphoric and cataphoric type nouns, but as stressed before they involve a very small percentage of the Subjects. This will be further discussed in the next chapter that discusses in further detail criteria used in the classification system for Subject.

The results using the new taxonomy are shown in Table 12. Previous results using the initial taxonomy presented in Chapter 3 are shown in parenthesis and italics:

Table 12 Results of the pilot study using the new taxonomy

SUBJECT	Paper J1	Paper J2
Participant	19% *(20%)*	23% *(24%)*
Discourse	4% *(5%)*	8% *(8%)*
Conventional	61% *(53%)*	40% *(15%)*
Instantial	16% *(22%)*	29% *(53%)*
TOTAL	100% *(100%)*	100% *(100%)*

As expected, the Participant and Discourse categories show virtually the same results. The differences are at the most of the order of 1%. This is due to the fact that in the original study, which was done at the beginning of this Ph.D. research, there were some cases of slightly different clause boundaries for the analysis of Theme, i.e. cases of hypotactical clauses having been analysed. This was corrected in the new analysis.

The most interesting outcome of the new taxonomy are the results concerning the Conventional and Instantial Categories. In very general terms, the new Conventional Category is nearer the previous Real World Category and the new Instantial Category is nearer the Hypothesised & Objectivized one. However, the criteria for the Conventional and Instantial categories are much tighter than for the original categories, with the result that instead of showing a high increase from 22 to 53% in Hypothesised & Objectivized Subjects, the new analysis shows a lower increase from 16 to 29% in Instantial Subjects.

This is explained by the fact that Subjects such as *'The 3D JJA model', 'Equation 1', 'Equation 2', 'Equations 1 and 2', 'Anisotropy', 'Disorder', 'Boundary conditions'* are now coded as belonging to the Conventional category because they are conventional wordings within the field of research concerned. Previously I had been in doubt whether to code as Real World - because they represented researchers' object of study - or as Hypothesised and Objectivised - because writers were treating theories, hypotheses, models and categories as objective entities by putting them in Subject role, although they were aware that such entities had a hypothetical status. In the pilot study I had settled for classifying them in the Hypothesised and Objectivised category, questioning whether I was inflating this category with elements belonging to a set of commonly used specialised terms that did not really show writer development. With the new taxonomy, the Instantial category shows a lower percentage than the previous Hypothesised and Objectivised category, as it now constitutes a more focused class. It still has to do with researchers' object of study. However, Subjects coded as belonging to the Instantial Category are now specially formulated elements which have been expanded for reasoning purposes.

Examples of Instantial Subjects from the pilot study are wordings in Subject position such as '*The percolation temperature T in the sense of the temperature at which P becomes finite (moves to lower temperatures indicating …)*', '*The same abundance of parameters defining the system (turns it difficult to find …)*', '*Some of the main parameters that define the behavior of the vortex structure (are …)*' and '*(We checked that) reducing the time step by a factor of ten (does not alter…)*'. To make the distinction between the Instantial and the Conventional category clearer, wordings in

Subject position such as '*The percolation temperature T …*' or '*Parameters…*' or '*The time step…*' on their own would be coded as belonging to the Conventional category. This brief presentation of the way Subjects have been coded is merely an introduction to the following chapter, which presents a detailed discussion of the new taxonomy. The same goes for the brief presentation of Contextual Frame in what follows.

4.6.2 Comparison of results for Contextual Frame

The comparison of results for Contextual Frame is much more difficult to make as the original categories are very different from the new ones. What the pilot study showed was a noticeable decrease of Minimum Logical Relations/Progression (i.e. mainly conjunctive Adjuncts and conjunctions, a class which roughly corresponds to the new Typical category) and, on the other hand, a noticeable increase of Evaluation, which roughly corresponds to the new Expressive Category. In the other three original categories, i.e. Maximum Logical Relations/Progression, Location and Goal and Process, which were grouped differently and subsequently coded under the Conventional and Instantial categories, there were virtually no changes.

Results using the later taxonomy confirm these trends, as shown in Table 13 below.

Table 13 Results of the pilot study using the new taxonomy for Contextual Frame

CONTEXTUAL FRAME	Paper J1	Paper J2
Typical	38%	31%
Conventional	27%	25%
Instantial	16%	18%
Expressive	19%	26%
TOTAL	100%	100%

However, when distinguishing subcategories within the four later categories, new trends start appearing. Detailed results are shown in Table 14.

Table 14 Results using the eleven subcategories of the new taxonomy for Contextual _

CONTEXTUAL FRAME		Paper J1	Paper J2
Category	Subcategory		
Typical	1 - Conjunctions and Conjunctive Adjuncts	37%	29%
	2 - Modal Adjuncts	1%	2%
Conventional	3 - Circumstantials of Location	18%	17%
	4 - Circumstantials of Cause and Condition	4%	2%
	5 - Other Circumstantials without Postmodification	5%	6%
Instantial	6 - Postmod. Circumstantials of Cause and Condition	-	-
	7- Other postmodified Circumstantials	6%	3%
	8 - Dependent Finite Clauses in Contextual Frame position	7%	9%
	9 - Dependent Non-Finite Clauses in Contextual Frame position	3%	6%
Expressive	10 - Clauses or Circumstantials plus Evaluation	14%	14%
	11 - Projecting Clauses	5%	12%
TOTAL		100%	100%

Table 14 shows that within the Typical Category there are very few modal Adjuncts, and that the decrease in this class is due to a decrease in coordination and conjunctive Adjuncts. Within the Conventional category there are no striking trends, except perhaps for Circumstantials of Cause and Condition diminishing by half, although these latter values are comparatively small. The most interesting results for subcategories show up in the Instantial and Expressive categories. In the Instantial Category we can see that first, there are no postmodified Circumstantials of Cause and Condition in either Paper J1 or Paper J2. Second, other postmodified Circumstantials diminish by half. Hence, the increase in the Instantial Category is all due to an increase in clause-type Contextual Frames. In these latter Contextual Frames, when subcategories 8 and 9 are taken together, their combined values go from 10 to 15%. This important increase in clause-type Contextual Frames was partly concealed when

the class was looked at as a whole, because postmodified Circumstantials diminished by half. In particular, more detailed results suggest that as the writer of Texts 1 and 2 gains experience, if he chooses to put in Contextual Frame position Cause and Condition type meanings, these are increasingly in clausal form. In general, postmodified Circumstantials decrease, whereas non-postmodified Circumstantials do not, except for Cause and Condition ones.

Finally, the important increase in the Expressive Category is entirely due to an increase in Subcategory 11, projecting clauses, that more than double, from 5 to 12%, whereas Subcategory 10 does not change from Paper J1 to Paper J2.

In sum, when results of the pilot analysis are looked at globally, either using the original classification in five categories or the new one in four, no noticeable differences appear in the results. Both taxonomies can be seen as showing a clear decrease in typical Contextual Frames of a more textual character, and an increase in Contextual Frames of a more interpersonal character (cf. Berry 1989, 1995). In contrast there seem to be no noticeable changes in the Contextual Frame categories of a more experiential nature, where it was initially presumed that differences in writer expertise might also show up. However, when the new taxonomy is made more delicate differences do appear, the most noticeable being that within the Instantial Category clause-type Contextual Frames increase, whereas Circumstantial-type Contextual Frames tend to decrease.

4.7 Statement of the research questions

The motivation for the pilot study was to look for traces of authorial development in the themes of two articles published by the same author, one at the beginning of his Ph.D., and the other at the end of his Ph.D.. The general research question that motivated the pilot study was the following:

General research question: As scientists gain experience as writers, are there perceivable changes in the choice of Themes in their published research articles?

On the basis of results obtained when doing the pilot study on the corpus of two articles, and on the subsequent design of new taxonomies for Subject and for Contextual Frame, research questions going from the general to the specific can now be stated for the analysis of the wider corpus of 30 articles. These research questions for Subject and for Contextual Frame are presented in turn.

4.7.1 Statement of the research questions for Subject

General research question for Subject: As scientists gain experience as writers, are there perceivable changes in the choice of Subjects in published research articles?

On the basis of this general research question for Subject, a further set of four more specific research questions motivated by the way in which the analysis has started to develop can now be posed:

Research Question 1 - As scientists gain experience as writers, is there a move towards the selection of Subjects which have been especially fashioned to create new, experiential wordings, and which sometimes may have an added interpersonal strand, i.e. towards Instantial Phenomena Subjects?

Research Question 2 - As scientists gain experience as writers, will there be comparatively less evidence of Conventional Phenomena Subjects? More precisely, will writers be able to design the kind of experiential wordings they need by using Instantial Subjects, and thus resort less frequently to the more conventional and pre-formulated expressions typical of their field of research?

Research Question 3: As scientists gain experience as writers, will there be relatively more evidence of Participant Subjects?

Research Question 4: As scientists gain experience as writers, will there be any noticeable trends in the selection of Discourse Subjects?

Research Question 1 asks whether there is evidence of an increase in Instantial Subjects and Research Question 2 whether there is a decrease of Conventional Subjects. Research Question 3 inquires about the possibility of an increase in overt authorial presence via Participant Subjects. Research Question 4 is an entirely open one, due in part to the low frequency of use of Discourse Subjects showing up in the pilot study, which makes the visualisation of significant trends more difficult.

4.7.2 Statement of the research questions for Contextual Frame

General research question for Contextual Frame: As scientists gain experience as writers, are there perceivable changes in the choice of Contextual Frames in published research articles?

It is comparatively easier to state particular research questions for Subject than for Contextual Frame, in part because filling the Subject slot is obligatory. When writers set up sentences in English, they cannot choose whether to put a Subject or not. Moreover, the most typical realisation of Subject is the nominal group (see for instance Downing and Locke 1995: 34). Hence, first Subject is obligatory, and second it has a prototypical - in the sense of 'most typical' - realisation. Research questions as to the ways choices in Subject change as writers gain experience can thus be suggested on the basis of a number of options opened to writers, but these options are more restricted (Subject is obligatory with a 'most typical' realisation) than those concerning Contextual Frame.

For Contextual Frames there is at the outset a choice: writers can choose whether to use the Contextual Frame slot or not. Previous studies (Montemayor-Borsinger 1995, 1999) focussing on different choices in research articles in Non-Newtonian Fluid Mechanics (NNFM) showed there were important differences in how frequently the Contextual Frame slot was used. In particular, a detailed analysis was made of two articles discussing exactly the same problem in NNFM. They had been written by the most prestigious research teams in the field, one working at the Massachusetts Institute of Technology in the United States and another working in Canada. In the MIT text just under a third of the Subjects were preceded by Contextual Frame, whereas in the

Canadian text two thirds were preceded by Contextual Frame. In the present corpus the range again is from just under a third to above two thirds of Subjects preceded by Contextual Frames.

Contextual Frame is an extra choice authors make when writing up. They decide whether or not to mark their Subjects. In some cases Contextual Frames are actually obligatory: there can be a strong logical component to Contextual Frames which implies that some of them are necessary for the flow of the text or for its organisation. Related to this is the fact that there are varying degrees of Theme markedness. Gosden, for instance, presents a cline of Contextual Frame markedness in declarative clauses in research articles going from more weakly marked to more strongly marked. More specifically, the cline progresses from conjunctions, to conjunctive and modal Adjuncts, to Circumstantial elements, to subordinate clauses (cf.1996:71). Likewise, the present chapter has introduced a coding system for Contextual Frames ranging from Typical to Conventional to Instantial Contextual Frames, and ending up with Expressive Contextual Frames which had an added interpersonal strand to already strongly marked Contextual Frame elements. Hence, the Contextual Frame slot can be filled in by many different elements, starting from the simple and more obligatory conjunctions and Adjuncts, to the more optional subordinate clauses.

There is no 'most typical' realisation for Contextual Frames as such. Because Contextual Frame is mostly optional with no 'most typical' realisation, the research questions concerning possible trends in Contextual Frame as writers gain experience rest on far wider ground than those concerning Subject. Nevertheless, it has been possible to identify four more specific questions motivated by the way in which the Contextual Frame analysis has started to develop in the pilot analysis. These are:

Research Question 5 - As scientists gain experience as writers will there be relatively less evidence of Typical Contextual Frames on their own? Will experienced writers tend to fashion more complex 'Instantial' Contextual Frames with multiple strands of meaning sometimes enclosing conjunctions and conjunctive/modal Adjuncts?

Research Question 6 - Will the use of Conventional Contextual Frames remain unaltered as scientists gain experience as writers? Will a given number of these commonly used Circumstantials within particular research fields be necessary for an optimum flow of text?

Research Question 7 - As scientists gain experience as writers, will there be a move towards the use of clause-type Instantial Contextual Frames expressing multiple strands of meaning?

Research Question 8 - As scientists gain experience as writers, will there be a move towards the use of more Expressive Contextual Frames with added interpersonal strands of meaning?.

4.8 Conclusion

The present chapter has presented the evolution of the original categories used for Subject and Contextual Frame in the pilot study to the new categories that will be used from now on for the corpus of 30 research articles. Steps have been taken towards establishing more reliable categories by looking in greater detail at grammatical

features, in order to detect in the most efficient way possible signs of writer development, both in Subject and in Contextual Frame. Metafunctional aspects have also been considered as adding different flavours to the various categories and might be kept in mind for the final discussion of results. The following chapter describes in more detail the actual criteria for the four Subject categories, and Chapter 6 will do the same for Contextual Frame.

Chapter 5 Detailed presentation of the criteria for each of the four Subject categories

5.1 Introduction

I present here an outline of the four different categories used for coding Subjects in my corpus of 30 research articles in physics: the Participant, Discourse, Conventional Phenomena and Instantial Phenomena categories. The Participant and Discourse categories are easier to distinguish by means of general linguistic criteria and, in particular, they belong to fairly well defined lexical sets. I shall therefore start by discussing these two less problematic categories in the following section.

A discussion of the Conventional Phenomena and Instantial Phenomena categories follows in Section 5.3. It is a much lengthier section divided into four parts. First, a rationale is given for using detailed grammatical criteria to help distinguish Conventional from Instantial Phenomena. Second, discourse and functional perspectives on the nominal group are presented to clarify the grammatical criteria used. In the last two parts of Section 5.3 detailed grammatical criteria for Conventional Phenomena and then for Instantial Phenomena are presented, together with examples from the extended corpus. Section 5.4 discusses the special cases of Existential-*There* and Anticipatory-*It* Subjects, as well as anaphoric and cataphoric type Subjects.

There are two main tables, Table 15 with examples of Conventional Phenomena Subjects and Table 16 with examples of Instantial Phenomena Subjects. Three

additional but minor tables, Table 17, Table 18 and Table 19 correspond to the last section just before the conclusion which discusses examples of Existential-*There*, Anticipatory-*It* and anaphoric/cataphoric type Subjects.

5.2 The Participant and Discourse categories

5.2.1 The Participant Category

Linguistic criteria: personal pronouns or nouns concerned with researchers and their work. Researchers choose to be visible/take responsibility or name colleagues in Subject position. The name for this category originally comes from Davies (1988) and concerns the writers themselves (e.g. *We* and *Our approach*), references to their colleagues (by name, e.g. *Lee and Stroud have discussed…)* and to studies related to their field of research. It also includes possessive forms relating to research outcomes when the author uses *our* as in *our data, our results*. In the present corpus an overwhelming majority of Participant Subjects, around 90%, are represented by *we*. Interestingly, there is not a single instance of *I*, although in 12 of the 30 papers a single researcher not only wrote the paper, but also did all of the research work alone.

5.2.2 The Discourse Category

Linguistic criteria: terms which belong to the highly conventionalised discourse of researchers naming parts of their work. The label for this category also originally comes from Davies (1988). It is a lexical set which includes words such as *Table 1, Figure 4, This section, The present paper* etc… which refer to the text and its parts and to the discourse acts of reporting and discussing.

Note that the same lexical terms preceded by *our* would be classified under Participant because authors would have chosen to be visible and thus take public

responsibility for their paper, table, etc. When the Subject being coded is worded as *Equation X…* it is not coded as belonging to the Discourse Category, but to the Conventional Phenomena Category discussed below. This is because when researchers choose *Equation X* as Subject, they are not referring to parts of the paper, but to what is the essence of their research work.

5.3 The Conventional and Instantial Phenomena categories

5.3.1 A rationale for criteria for the Conventional and Instantial Phenomena Categories

Both Conventional Phenomena and Instantial Phenomena Subjects refer to entities and events belonging to experiments and theory within the realm of physics. However, when researchers choose to place these objects of study in Subject position, they can choose wordings which draw upon the resources of pre and post modification, which in very subtle and important ways affect meaning. Moreover, because of the characteristics of physics research articles, which are texts meant for a highly specialised audience of fellow physicists, meaning in these texts, and especially some of the more subtle and important meanings I am trying to identify, can often be very difficult for the linguist to recover. Signs within the text, such as pre or post modification, are of great help in recovering these more subtle types of meaning. Discourse and functional views on the structure of nominal groups were reviewed in Section 4.4 where detailed grammatical criteria were discussed. In particular, 'Of-type' nominal groups, which are the predominant forms taken by Subjects in corpora in general and in the present corpus, were looked at in the light of Sinclair (1991, Chapter 6). We saw that '*of*' was mainly used in association with other nouns to produce new meanings, either by introducing a second noun as a potential headword, or by forming

double-headed nominal groups. In the case of new meanings being formed on the basis of double-headed nominal groups, neither noun seemed to be more significant or dominant, and to express these new meanings the *'of'* structure tended to require both nouns.

Sinclair's insights are used here for added judgement in discerning between Conventional Phenomena and Instantial Phenomena categories. Criteria will be presented for both categories, and will be illustrated by examples from the present corpus.

5.3.2 Characterisation of the Conventional Phenomena category

We saw in the previous chapter that the Conventional Phenomena category is realised by elements, mostly of a taxonomising type, that refer to entities and events belonging to experiments and theory within the realm of physics. These elements belong to the specialised language that is commonly used in this field of research, and typically do not contain interpersonal elements.

In the Conventional Phenomena category, Subjects are realised by nouns or 'of-type' nominal groups characterised by:

optional pre-modification by items such as deictics, numeratives and classifiers

optional pre-modification by epithets describing an objective property of the Phenomenon in question

absence of postmodification except 'of-type' nominal groups. Following Sinclair (1991) 'of-type' nominal groups are not seen as introducing prepositional phrases which function as Adjuncts, but rather as introducing a second noun as a potential headword, or as forming double-headed nominal groups. For instance, when new meanings are formed on the basis of double-headed nominal groups, neither noun seems to be more

significant or dominant, and to express these new meanings the *'of'* structure tends to require both nouns.

In the following, criteria for Conventional Phenomena Subjects are accompanied by examples from my corpus. In Table 15 the sample Subjects , in italics, are presented in the clause complex in which they occur. For every case study, two papers have been taken, and a Conventional Phenomena Subject has been chosen from each of the two papers. In the table there is a capital letter followed by a number in parenthesis after each example, indicating the paper it was taken from. In the text, the Subjects are also in italics, a capital letter indicating an unmarked Subject which begins a sentence, and a lower case letter indicating a marked Subject preceded by a Contextual Frame. Every Subject is accompanied by square brackets indicating the number of the example it corresponds to in Table 15.

Table 15 Examples of Conventional Subjects (in italics) two for each case study from two different papers.

	CONVENTIONAL PHENOMENA SUBJECTS
1	Under a magnetic field H *the compound* undergoes a transition to a ferromagnetic state, at very low temperatures and at normal pressure. (A1)
2	*The three EPI's* [effective pair interactions] are obtained from first-principles linear-muffin-tin orbital (LMTO) calculations. (A3)
3	*The field of semiconductor microstructures* has also profited from this technique. (E2)
4	*The term fluorescence photobleaching recovery spectroscopy (FPRS)* has been coined as a general description of this method. (E3)
5	*The inverse of D* as usual can be calculated by a perturbation expansion. (F1)
6	*The bosonized action $S_{bos}(A)$* is then given by a generalised functional Fourier transform of $Z(b)= \exp [-W(b)]$: *Equation*. (F3)
7	Following the work by Frisk [20] *the liquid phase* was described by adopting a substitutional solution model, (G2)
8	*The program* optimises the parameters that are set free to vary, (G3)
9	Furthermore, *memory-type phenomena* take place in the dynamics of the particles (M1)
10	However, *gravitational fields in astrophysical systems* can be considered as weak, even in the extreme cases of the neighborhood of a neutron star (M3)
11	However, no *J values* were reported in this case. (O1)
12	Finally, *this photoassisted oxygen ordering* might help to understand the differences observed between the short and long-time illumination experiments. (O2)
13	*The asymptotic form of the wavefunction* can be corrected by multiplying each molecular orbital (P2)
14	*The first and second-order Born approximations* present a range of agreement with experiments compatible with the condition Zi/v (P3)
15	Here *n* is an impurity phase shift. (Pro1)
16	Besides this technical difference, *the generalized Coulomb potentials* are quite similar for both geometries. (Pro3)
17	*The ratio dH/dE* is appreciably changed for both types of fermions. (T1)
18	*The ground state* will be shifted below or above the zero energy point depending whether q > 1 or q < 1. (T3)
19	*The nonlinear partial differential equation (2.10)* is equivalent to the original Boltzmann equations. (Z1)
20	Finally, *reaction-diffusion equations* have been obtained for the macroscopic density of a system undergoing reaction processes, in which particles are created or destroyed. (Z2)

Examples of typical Conventional Phenomena Subjects which are nouns on their own or 'of-type' nominal groups are: *the compound* [Example 1], *the field of semiconductor microstructures* [Example 3], *The asymptotic form of the wavefunction* [Example 13], *The ratio dH/dE* [Example 17].

Examples of the type of pre-modification which can accompany Conventional Phenomena are: *fluorescence photobleaching recovery spectroscopy* [Example 4], *The nonlinear partial differential equation (2.10)* [Example 19]. This type of pre-modification can be achieved through the use of items[19] such as:

deictics - *this* in *this photoassisted oxygen ordering* [Example 12])

numeratives - *three* in *The three EPI's* [Example 2]

classifiers - *fluorescence photobleaching recovery, asymptotic,* and *nonlinear partial differential* [from previous Examples 4, 13 and 19], and *reaction-diffusion* in *reaction-diffusion equations*[Example 20]). Subjects can also be pre-modified by an epithet if the epithet describes an objective characteristic of the entity being discussed: *photoassisted* [from Example 12], *generalized* in *the generalized Coulomb potentials* [Example 16]. However, if the epithet expresses an Interpersonal perspective such as the scientist's attitude or stance towards the entity, as in *A new and interesting feature of the high-ir, superconductors*, for instance, then it will not be included in the Conventional Phenomena category, but in the Instantial Phenomena category discussed below.

As detailed above, there is no postmodification in the Conventional Phenomena Category, or, put in functional terms, there are no elements which would come after the Thing and function as Qualifier. There are very rare cases of what could be seen as

[19] The nomenclature used here follows the one used by Halliday when he discusses the nominal group in his Chapter 6 of *Introduction to Functional Grammar* – 1994:180-196

postmodification by prepositional phrases starting with *in* or *for*. However, a closer analysis shows that in these rare cases these prepositions seem to take on the typical *'of'* function discussed by Sinclair of combining with other nouns to produce new meanings, and can actually sometimes be replaced by *of* . One example where a second noun has been introduced as a potential headword is *gravitational fields in astrophysical systems* [Example 10], which has been coded as belonging to the Conventional Phenomena category.

5.3.3 Characterisation of the Instantial Phenomena category

The term 'Instantial' has been taken from Halliday (1998) and is used here in his sense of wordings especially created for the immediate requirements of reasoning within a particular stretch of discourse. Like the Conventional Phenomena category, the Instantial Phenomena category is also realised by elements that refer to entities and events belonging to experiments and theory within the realm of physics. However, the difference is that these Subjects have been especially formulated by researchers to produce certain types of more complex meanings.

These more highly crafted elements are needed, for instance, to 'package' information in resourceful and innovative ways in the Subject slot. The choice of Instantial Phenomena can also be the first wordings of something new. In these two cases of packaging information and of new wordings, the researcher may need to form complex nominal groups containing embedded clauses and phrases. Instantial Subjects are also used for issues that may not yet be established, and may be concerned with interpretation or controversy, in which case authors resort both to modification and to interpersonal elements. Alternatively, Instantial Subjects are used by writers once they have absorbed and made their own the substance with which they are working. In all

these cases there is authorial presence, either because authors have modified Subjects in such an extensive way that they no longer belong to the purely taxonomic jargon of their area of research, or because authors have introduced interpersonal elements within the Subject slot.

In contrast, we have seen above that Subjects in the Conventional Phenomena category identify elements that are taken for granted and which are already established. They are commonly used terms not specially created for a particular stretch of discourse, but rather belonging to the taxonomic system of the research field concerned.

In this category, nouns or 'of-type' nominal groups concerning the object of study of the researcher are accompanied by at least one of the following components:

pre-modification by interpersonal epithets expressing the scientist's attitude or stance

postmodification by prepositional phrases or relative clauses functioning as Qualifiers

the nouns themselves contain lexical or contextual clues indicating interpersonal meanings

I shall now illustrate how these elements are identified on the basis of the examples in Table 16. After each example a capital letter followed by a number in parenthesis indicates the paper the example was taken from.

Table 16 Examples of Instantial Subjects (in italics), two for each case study from different papers.

	INSTANTIAL SUBJECTS
1	*The magnetic susceptibility that in other intermediate valence compounds shows a maximum at some finite temperature* increases monotonically with decreasing temperature, until order sets in. (A1)
2	*The other extreme approach, valid in principle only for good metals,* neglects completely the correlations. (A3)
3	In addition, *inelastic light scattering experiments for light propagating along the planes of the structure* are possible. (E2)
4	In particular, *the geometrical aspects of the illuminating optics and the imaging method to monitor the fluorescence emission (normal, confocal, etc.)* determine the type of experiment under consideration. (E3)
5	*Whether a chiral gauge theory (CGT) with an arbitrary fermion content can be consistently quantized or not* is still an open question. (F1)
6	*The generating functional ${\cal Z}(A)$ for massless fermionic fields in the presence of an external gauge field A in a D-dimensional Minkowski spacetime~* is defined by *Equation* where *Equation* and *Equation* where τ_a are (anti-hermitian) generators of the Lie algebra of the non-Abelian gauge group, and both ${\cal A}_\mu$ and ${\cal A}_\mu^a$ are real. (F3)
7	*The effective force constant for the metastable FeN, nitride (Sect. 2.5), which has not been available,* was estimated in the present study by a smooth extrapolation of the k, versus x,, curve for nitrides (solid line), (G2)
8	*The failure in achieving a satisfactory representation of the selected data* leads to various kinds of modifications of the previous decisions. (G3)
9	*The demonstration here presented* implies a new deduction of the Rayleigh-Jeans law, (M1)
10	In fact, *the strongest evidence of the universality of the gravitational interaction* involves electrons, protons and neutrons, that is the members of the lightest family of matter fields in the standard model. (M3)
11	*A new and interesting feature of the high-ir, superconductors* was clearly demonstrated by the experiments of Müller et al. [1] in ceramic LaBaCuO. (O1)
12	In view of these experimental facts, *the argument used in Ref. 7* is no longer valid. (O2)
13	*The velocity field coming from the phase factor* is adjusted to describe the density flux provided by the time dependence of the molecular basis (P2)
14	*Attempts to free the results from the selection of distorting potentials* may not be pursued through a neglect of the effects brought by long-range forces on the transition amplitudes. (P3)
15	For our problem, *the equations corresponding to the eigenstates with total spin**** take the form: *Equation (24)* where the M unequal numbers * satisfy the equations: *Equations (25)*.(Pro1)
16	Physically, *the weak dependence of the excitonic energy with the dielectric contrast* reflects the charge neutrality of the exciton. (Pro3)
17	Joining together eqs. (4.13), (4.14) and (4.15), *the only coefficients that survive* are ** related by *Equation (4.16)*. (T1)
18	*The condition of star representation for the action of ~1~ on these particular scalar products* is [Equation (30)] (T3)
19	*A particular case which can be solved in a closed form* is given by the situation in which remotion and regeneration events are neglected. (Z1)
20	*The reaction-diffusion equations obtained from the asymptotic expansion* coincide with those proposed ad hoc at the macroscopic level to describe the evolution of the density. (Z2)

Every single Subject from Table 16 - twenty in all - is discussed in what follows. Once more, Subjects starting with a capital letter are unmarked, and the ones starting with lower case are marked by a Contextual Frame.

1.- *The magnetic susceptibility that in other intermediate valence compounds shows a maximum at some finite temperature* - In this example *magnetic susceptibility*, which on its own would have been classified as Conventional Phenomena, has been postmodified by the researcher with a defining relative clause especially worded in order to give an adequate frame for the ensuing Rheme.

2.- *The other extreme approach, valid in principle only for good metals,* - Here there is both interpersonal pre-modification, i.e. *extreme*, and post modification *valid in principle only…* which prepare the reader for further comment in Rheme, i.e. *neglects completely the correlations.*

3.- *inelastic light scattering experiments for light propagating along the planes of the structure* - This example is similar to Example 1. *Inelastic light scattering experiments* on its own would have been classified as Conventional Phenomena. However the researcher has added extensive postmodification, pushing this Subject into the Instantial Phenomena category.

4.- *the geometrical aspects of the illuminating optics and the imaging method to monitor the fluorescence emission (normal, confocal, etc.)* - Again, a similar example to 1 and 3: *the geometrical aspects of the illuminating optics and the imaging method* would be coded as Conventional Phenomena, although the wording *aspects* might have an 'Instantial Phenomena flavour' to it. Further postmodification indicates clearly that this Subject belongs to the Instantial Phenomena category.

5. - *Whether a chiral gauge theory (CGT) with an arbitrary fermion content can be consistently quantized or not* - Here the researcher has very cleverly built in his stance towards a problem by this Instantial Phenomena Subject which is followed by the Rheme *is still an open question*.

6. - *The generating functional ${\cal Z}(A)$ for massless fermionic fields in the presence of an external gauge field A in a D-dimensional Minkowski spacetime~* - Here again, as in examples 1, 3 and 4, it is extensive postmodification which helps to code this Subject within the Instantial Phenomena category.

7. - *The effective force constant for the metastable FeN, nitride (Sect. 2.5) which has not been available* - Same as Examples 1, 3, 4 and 6.

8. - *The failure in achieving a satisfactory representation of the selected data* - Here we have an interesting example of interpersonality transpiring not only in the noun *failure*, but also being reinforced by wordings in the postmodification, especially by the word *satisfactory*.

9. - *The demonstration here presented* - This Subject belongs to the Instantial Phenomena category because of the postmodification *here presented,* which could be reworded, for instance, as *we present here,* indicating authorial presence and thus interpersonality.

10. - *the strongest evidence of the universality of the gravitational interaction* - Here *evidence* is pre-modified by the epithet *strongest* manifesting the scientist's position, giving this Subject from the very beginning a strong Instantial flavour which is then strengthened by extensive postmodification.

11.- *A new and interesting feature of the high-ir, superconductors* - Here we have another very good example of pre-modification by the epithets *new and interesting*

expressing the scientist's attitude vis-à-vis *a feature of the high-ir, superconductors*. The latter 'of-type' noun on its own would have been classified as a Conventional Phenomena Subject.

12. - *the argument used in Ref. 7* - The word *argument* is postmodified in a highly interpersonal way, where the researcher cites another work and then says in Rheme that this work *is no longer valid.*

13. - *The velocity field coming from the phase factor* - Same as Examples 1, 3, 4, 6 and 7. *Velocity field* on its own would be coded as Conventional Phenomena, but postmodification in the form of *coming from the phase factor* places this Subject in the Instantial category.

14. - *Attempts to free the results from the selection of distorting potentials* - This Subject is similar to Example 8 in that interpersonality emanates not only from the noun *Attempts*, but also from the wording of the postmodification *to free the results*. A question arises concerning the epithet *distorting* in *distorting potentials*: is it an objective property of *potentials*, or does it express the researcher's subjective attitude towards *potentials*? In the present case it actually belongs to the set of commonly used terms within Atomic and Molecular Physics, the field of research of the paper concerned. However, the doubt which could have arisen concerning *distorting potentials* is not a serious one, as grammatical criteria (i.e. multiple postmodification of Attempts) places this Subject definitely in the Instantial Phenomena category.

15. - *the equations corresponding to the eigenstates with total spin**** - Same as Examples 1, 3, 4, 6, 7 and 13.

16. - *the weak dependence of the excitonic energy with the dielectric contrast* - Here if the 'of-type' noun *the weak dependence of the excitonic energy* was on its own, there

could arise the same question as in Example 14, this time about the epithet *weak*: does it express an objective property of the thing itself, or is it the expression of the researcher's attitude towards *dependence*? Here again, within Condensed Matter, the field of Physics concerned, it is a commonly used concept. However, because of the postmodification *with the dielectric contrast* introduced by the researcher, this Subject is coded as being Instantial Phenomena.

17.- *the only coefficients that survive* - In this example *only* could be a clue for including this Subject in the Instantial Phenomena category as the researcher has chosen to define a very particular subset of *coefficients*. Moreover, the added postmodification is an additional indication of it being coded as Instantial Phenomena.

18. - *The condition of star representation for the action of ~1~ on these particular scalar products* - This Subject is coded as Instantial Phenomena because of extensive postmodification by a series of prepositional phrases.

19.- *A particular case which can be solved in a closed form* - Both the pre-modifying epithet *particular* and the post-modifying *which* clause makes this Subject Instantial Phenomena.

20.- *The reaction-diffusion equations obtained from the asymptotic expansion* - Same as Examples 1, 3, 4, 6, 7, 13 and 15.

5.4 Special cases

5.4.1 Existential-*There* and Anticipatory-*It*

Existential-*There* and Anticipatory-*It* Subjects represent a very small percentage of the 4425 Subjects of the present corpus: 2 % for Existential-*There* and less than 2 % for Anticipatory-*It*. Both are clearly recognisable lexical forms which are coded as

Conventional or Instantial Phenomena according to the element to which they point forward, as will be seen in subsections 4.1 and 4.2.

5.4.1.1 Existential-There

In the present sample existential-*There* constructions typically have a strong cataphoric flavour. In the corpus they are coded as Conventional Phenomena or Instantial Phenomena, depending on the element to which they point forward. Because in the corpus Existential-*There* constructions mainly point forward towards heavily postmodified elements, three out of four Existential-*There* Subjects are coded as Instantial Phenomena. Existential-*There* helps maintain a smoother flow of discourse than if the associated postmodified elements were placed in the usual pre-verbal Subject slot. To illustrate this point, I have chosen ten examples of Existential-*There* constructions coded as Instantial Phenomena, one for each case study, and present them in Table 17 below. This table shows Existential-*There* constructions in context, one for each case study. A capital letter indicates that *There* is not preceded by a Contextual Frame. A small case *there* indicates a preceding Contextual Frame. After each example a capital letter followed by a number in parenthesis indicates the paper from which the example has been taken.

Table 17 Instantial Subjects of the Existential-There type.

1	*There* are many ways of expressing the coefficients A(Q,I) in terms of the A(e;I) for two arbitrary regions X~ and Xp by repeated application of Eqs. (3.9) and (3.10). (A2)
2	*there* will be a region within the illuminated area of HeNez where the dyes exhibit less fluorescence. (E3)
3	*There* is usually more than one way to construct such linearized representations. (F2)
4	*There* is some more thermochemical information available from experiments which was not used in the present evaluation. (G1)
5	*There* is another interesting approach, not considered here, based on the introduction of a new physical concept, the chronon, that leads to a finite-difference rather than an integro-differential equation of motion (4), which also accounts for a satisfactory behaviour. (M1)
6	*there* is an oxygen dependent distribution of trapping energies which together with the recombination dynamics could give rise to the saturation of the photoenhancement of T, and a,b. (O2)
7	*there* are still questions to be answered and points to clarify. (P3)
8	*There* is also a maximum value of d for the validity of our calculation approximately given by *** because for d >d,,, the system will have a transition from a semiconductor to a semimetal configuration, as a consequence of the transfer of electrons from the valence band to the conduction band. (Pro2)
9	*there* is a natural definition of an action of d~ on ~. (T3)
10	*there* exists a similarity solution whose width grows as t'/(2+k). (Z2)

In Example 1, for instance, an alternative wording could have been *Many ways of expressing the coefficients A(Q,I) in terms of the A(e;I) exist for two arbitrary regions X~ and Xp by repeated application of Eqs. (3.9) and (3.10).* However, exist does in some measure interrupt the flow of postmodification. An even clearer illustration of how the verb can get in the way of postmodification is Example 2, which could have been worded in the more cumbersome form *A region within the illuminated area of HeNez exists where the dyes exhibit less fluorescence*. The same rewording could be done for all ten examples, and in all cases there would be a slight interruption in the course of postmodification, probably resulting in a more staccato flow of discourse.

5.4.1.2 Anticipatory-*It*

It is coded as Conventional Phenomena or Instantial Phenomena, depending on its function. If *It* is a personal pronoun referring to Conventional Phenomena the researcher

is talking about, it is coded as such. However, if *it* is part of a construction especially formulated by the researcher with the double purpose of indicating opinion and avoiding overlong Subjects by placing what is being talked about at the end of the sentence, it is coded as Instantial. With respect to overlong Subjects, it again has to do with facilitating the flow of discourse. To illustrate this point I shall refer to examples taken from the present corpus presented in Table 18 below. In a similar way to Existential-*There*, one Anticipatory-*It* construction per case study is shown. A capital letter indicates that *It* is not preceded by a Contextual Frame. A small case *it* indicates a preceding Contextual Frame. After each example a capital letter followed by a number in parenthesis indicates the paper the example was taken from.

Table 18 Instantial Subjects of the Anticipatory-It type

1	*it* is sufficient to take into account only the first nearest neighbors of the Cu ions of the CuO, planes. (A3)
2	*it* is actually possible to observe the heavy- and light-hole reemission from the side. (E2)
3	*it* seems important to understand the structure of their constraints. (F1)
4	*It* is a difficult problem to know how a proper weight can be assigned to each piece of information.
5	*it* is easy to find the solution for an arbitrary level, as in the preceding example.(M2)
6	*it* will not be possible to trigger the mechanism. (O2)
7	*it* is easy to relate Green operators for the full system with those of the scattering channels *Equation (36), Equation (37),* with n = D,C.(P3)
8	*it* will be quite difficult to obtain experimental information about the shape of quantum dots from measurements of excitonic properties.(Pro3)
9	*It* is interesting to note the following fact.(T1)
10	*It* is therefore enough to analyze, for instance, the four solutions with XlaO.(Z3)

In all the examples - one representative example for each case study - we can see an evaluative epithet, marked in bold in Table 18, followed by a *to*-infinitive clause recommending what has to be done or saying that something is necessary. If these examples are reworded without using Anticipatory-*It*, the new sentences become top-heavy and awkward. For instance, let us reword the first two examples: *To take into*

account only the first nearest neighbors of the Cu ions of the CuO, planes is sufficient (Example 1) *To observe the heavy- and light-hole reemission from the side is actually possible* (Example 2). Moreover, the flow of discourse is interrupted as the subsequent Themes do not pick up on *sufficient* and *possible*. An even clearer example of how cumbersome a sentence can become without the use of Anticipatory-*It* is Example 7, where the researcher had to find an effective way of sequencing relevant information in a sentence with two equations. The original sentence goes:

It is easy to relate Green operators for the full system with those of the scattering channels

$G^{+}(t_2,t_1) = G_n^{+}(t_2,t_1) - i \int dt\, G^{+}(t_2,t)\, Vn(t)\, G_n^{+}(t,t_1)$ (36)

$= G_n^{+}(t_2,t_1) - i \int dt\, G_n^{+}(t_2,t)\, Vn(t)\, G^{+}(t,t_1)$ (37)

with n = D,C.

Whereas a reworded text without the use of Anticipatory-*It* would have been:

To relate Green operators for the full system with those of the scattering channels

$G^{+}(t_2,t_1) = G_n^{+}(t_2,t_1) - i \int dt\, G^{+}(t_2,t)\, Vn(t)\, G_n^{+}(t,t_1)$ (36)[20]

$= G_n^{+}(t_2,t_1) - i \int dt\, G_n^{+}(t_2,t)\, Vn(t)\, G^{+}(t,t_1)$ (37)

with n = D,C is easy.

In this latter reworded version, as in the previous two examples, the flow of discourse would be interrupted because in the original version the following sentence picks up on the Rheme, i.e. the scattering functions (36) and (37), and not on the easiness of relating Green operators to scattering functions. The original chunk of text thus goes:

It is easy to relate Green operators for the full system with those of the scattering channels

$G^{+}(t_2,t_1) = G_n^{+}(t_2,t_1) - i \int dt\, G^{+}(t_2,t)\, Vn(t)\, G_n^{+}(t,t_1)$ (36)

$= G_n^{+}(t_2,t_1) - i \int dt\, G_n^{+}(t_2,t)\, Vn(t)\, G^{+}(t,t_1)$ (37)

with n = D,C.

Integral equations for the scattering wave functions ψ result from applying (36,37) to the channel wave functions ϕ, X

$\psi^{+}(t)\rangle = \phi_i(t)\rangle - i \int dt' G^{+}(t,t') V_D(t') \phi_i(t')\rangle$, (38)

$\psi^{-}(t) = \langle X_f(t) - i \int dt' \langle X_f(t') V_C(t') G^{+}(t',t)$. (39)

5.4.2 Anaphoric-noun and Cataphoric-noun type Subjects

The percentage is even smaller - well under 1 % - for a class of Subjects I shall call, in part after Francis, Anaphoric-Noun type Subjects, adding the nomenclature 'Cataphoric-noun'. I adopt in part Francis' nomenclature because these types of Subject share many of the characteristics of the Anaphoric Nouns she discusses in her 1986 paper. In contrast with the other Instantial Subjects where there are additional grammatical criteria pointing towards their inclusion in Instantial Phenomena rather than in Conventional Phenomena, and for Existential-*There* and Anticipatory-*It* which are coded according to what element they point forward to, these Anaphoric-Noun type Subjects are classified as Instantial for more lexical and contextual reasons, which makes them interesting to discuss briefly, although they represent such a small percentage.

The reasons for the inclusion of such Subjects in the Instantial category are often given by lexico-semantic clues indicating interpersonal meanings, e.g. *criticism*. Contextual clues can sometimes be given by the presence of deixis - actually a

[20] For the sake of editing simplicity, Equations 36, 37, 38 and 39 are truncated

grammatical sign. Deixis can add an Instantial flavour to what looks like a Conventional wording because it anchors the message to the context, and thus has been created precisely for that specific portion of discourse. Subjects of these types are shown in Table 19 below.

Table 19 Anaphoric or Cataphoric-noun type Subjects coded as being Instantial

Anaphoric Noun type Subjects in the Corpus	
Paper	Wordings
A2	the whole problem
A3	the criticism
A3	The theoretical discussion
E2	This tendency
E3	All these configurations
E3	This latter property
E3	This situation
F1	Such a question
F1	the above statements
F2	this simplicity
F3	this redefinition of the fermionic fields
G1	These various choices
G2	the present evaluation
G2	Such an iterative procedure
G3	This problem
M2	The interpretation of the first operator
M2	these procedures
M3	Two questions
M3	Other possibilities for the equation
M3	This approximation
P3	This expectation
P3	the difficulty
Pro1	this ambiguity
Pro3	no obvious cancellation
T2	The problem of constraints
T2	a possible solution
T3	Such constructions
T3	Other aspects
Z2	much attention

Francis (1986) points out that the function of an Anaphoric noun is to label preceding stretches of discourse which are thus integrated in the general flow of

argument and are typically heavily context dependent. By choosing certain types of noun, such as for instance *this ambiguity*, the writer is not only labelling a preceding stretch of discourse, but is also indicating to the reader that s/he considers what has been discussed before as ambiguous. In Francis' words "In interactive terms, then, A-nouns are highly informative, contributing to provide the reader with a conceptual framework for understanding the writer's plan" (1986:39). I shall not discuss further this type of Instantial Subject because it represents such a small proportion of the total.

I have added the word cataphoric to the Francis labelling, because some of these nouns, which we should remember function here as Subjects (in Francis' case this was not necessarily so), could also point forwards. In the present corpus there are fewer than a dozen such Subjects, and perhaps the best example would be *two questions* (M3). Here is the sentence within which this expression functions as Subject:

With respect to the first point, two questions arise naturally: the validity of general relativity as a description of the gravitational interaction, and the universality of this interaction.

The word *question* could be taken as indicating stance and discussion. However, this lexical criterion alone would not be strong enough to code this Subject as Instantial Phenomena. It has been coded as belonging to the Instantial Phenomena category for contextual reasons as it points forward to the following highly interpersonal Rheme *arise naturally: the validity of general relativity as a description of the gravitational interaction, and the universality of this interaction.*

5.5 Conclusion

A detailed discussion of the criteria for each Subject category has been presented. The discussion has centred on the categories whose Subjects are more difficult to code, i.e. on the Conventional and Instantial Categories. These differ in that Conventional Subjects are wordings which are readily available, whereas Instantial Subjects are wordings which have had to be especially composed. However, coding difficulties are probably due more to their similarities than to their differences. We saw in Chapter 4 and in the present chapter that both categories have to do with the object of study of the researcher. Both categories tend to deal with abstractions sometimes involving grammatical metaphor, albeit different types of grammatical metaphor. Both categories can also have special Subjects of the Existential-*There* type, or of the Anticipatory-*It* type. What has helped to distinguish these categories has been bringing to bear additional lexico-grammatical criteria, and, in the case of special Subjects, additional contextual criteria. The latter type of criteria have also helped to code Anaphoric and Cataphoric type Subjects in the Instantial category.

Chapter 4 showed that related difficulties were encountered when trying to code Contextual Frames. It described the process that led to observing that some Contextual Frames seemed to be more typical and conventional[21] than others, which seemed to be more fashioned to fit particular instances of discourse, sometimes with an additional interpersonal strand. On the basis of these observations, the four Contextual Frame categories of typical, Conventional, Instantial and Expressive were identified. The

[21] In the present thesis the words 'typical' and 'conventional' are only capitalised when they label classes, but not when they are used as common adjectives.

following chapter will discuss detailed criteria for the four Contextual Frame Categories, and the eleven sub-categories that were subsequently distinguished.

Chapter 6 Detailed presentation of the criteria for Contextual Frame categories and subcategories

6.1 Introduction

In parallel to the previous chapters on Subject, the purpose of studying Contextual Frames in the thirty papers of the corpus is to find out whether there are any changes in their wordings as scientists gain experience in writing research articles. This chapter presents four different categories for Contextual Frames: 'Typical', 'Conventional', 'Instantial' and 'Expressive' Contextual Frames. The Typical and Conventional Categories of Contextual Frames are fairly easy to recognise. The Typical Category is realised by conjunctions, conjunctive and modal Adjuncts, and the Conventional Category by Circumstantials which have not been postmodified. However, already in the Conventional Category there can be problems when trying to code more precisely the types of meanings expressed by these non postmodified Circumstantials.

The Instantial and Expressive Categories are much more difficult to classify because they tend to be realised by all sorts of elements, ranging from postmodified Circumstantials to finite and non-finite clauses often expressing Cause, Condition and Manner, where it is common not only for boundaries to overlap, but also to find several meanings present in one Contextual Frame. Multiple meanings being present in one Contextual Frame actually signifies that it should be coded as belonging to the Instantial Category. I shall further explain in the corresponding section the difficulties involved.

Contextual Frames have been coded according to the four broad categories mentioned above, which in turn have been subdivided into eleven subcategories. The purpose of subdividing the four broad categories into further subcategories is to maximise the probability of detecting relevant trends for the present longitudinal study of Contextual Frame choices. For tendencies to show up it is necessary to use a classification system which is as explicit and as effective as possible. This means striking a balance between using too simplistic or, on the contrary, exceedingly detailed classifications. By distinguishing subcategories within the four categories, it is hoped that the coding system will be delicate enough to consider the richness of the different ways meanings have been worded, and at the same time effective enough to detect significant trends.

The important point to remember is that Contextual Frames from the Typical and Conventional Categories are realised by clearly recognisable linguistic elements, in the first case by conjunctions and Adjuncts and in the second by Circumstantials. Contextual Frames from the Instantial and Expressive category are expressed either by modified Circumstantials or by finite or non-finite clauses, and are thus characterised by expressing multiple meanings.

The consequence of the above for the subcategories is the following. In the Typical and Conventional Categories, it is possible to distinguish subcategories broadly based on the types of meanings expressed. For the Instantial and Expressive categories this is much more difficult to do, precisely because extensive modified or clause-type Contextual Frames tend to express multiple meanings. Thus, subcategories for these latter categories will need more detailed grammatical criteria showing how the meanings have been expressed, e.g. whether the meanings involved have been

expressed by postmodified Circumstantials, or by different kinds of clauses such as finite and non-finite clauses, or projecting clauses.

The present chapter is organised as follows. Sections 6.2 to 6.5 discuss the criteria used for each Contextual Frame category in turn. These four sections present some of the difficulties involved in the coding system, and give examples for each category. Section 6.6 takes up again the issue of finding a balance between delicacy and effectiveness in the taxonomy proposed here.

6.2 Typical Contextual Frames: Subcategories 1 and 2

'Typical' Contextual Frames are realised by conjunctive Adjuncts and modal Adjuncts. Halliday has qualified these elements as having a special thematic status in the clause: they are all at least typically thematic, with a small sub-set, e.g. *and* & *but*, being actually obligatorily thematic. All these elements will be classified here as being 'Typical' Contextual Frames, with two subcategories. Subcategory 1 is realised by conjunctive Adjuncts, and Subcategory 2 by modal Adjuncts.

Conjunctive Adjuncts are typically thematic because their function in discourse is to relate the clause to which they belong to the preceding text, and modal Adjuncts are typically thematic because they present writer point of view regarding what follows:

'It is not difficult to see why modal and conjunctive Adjuncts tend to come at the beginning of the clause: if one of them is present at all, then in a sense it is a natural theme. If the speaker includes within the message some element that presents his or her own angle on the matter, it is natural to make this the point of departure: "I'll tell you what I think". Similarly, if there is some element expressing the relationship to what has

gone before, by putting this first we thematize the significance of what we are saying: "I'll tell you how this fits in".' (Halliday 1994: 49-50, capitals as in the original)

Regarding the Subcategories of conjunctive and modal Adjuncts, it is interesting to note that there are sometimes fuzzy boundaries between the two. Halliday himself has classified for instance *In fact* as a conjunctive Adjunct, more specifically Verificative (IFG:49), but then has also classified it as Adjunct of Mood / Intensity (IFG:83).

Sometimes there are also fuzzy boundaries between modal Adjuncts and elements such as Circumstantials of Manner/Quality. Examples from my corpus are for instance *Accordingly* and *More precisely*. In the present classification, when such borderline elements are expressed by a *ly*-type adverb such as the above, I have classified them as belonging to the modal Adjunct class rather than the Circumstantial one. However, when such elements are expressed by prepositional groups which include a preposition followed by a nominal unit (Downing 1992:582) such as *In this way*, the latter is coded as a Circumstantial belonging to Conventional Contextual Frames.

6.3 Conventional Contextual Frames: Subcategories 3, 4 and 5

Conventional Contextual Frames are realised by different types of Circumstantials which have not been postmodified, except for certain 'of-type' nominal groups discussed previously[22], and are part of the specialised terms commonly used by researchers in their particular field of research. Three subcategories have been distinguished within the Conventional category, Subcategory 3, Circumstantials of Location, Subcategory 4, Circumstantials of Cause and Condition and Subcategory 5,

[22] Following Sinclair (1991) 'of-type' nominal groups are not seen as introducing prepositional phrases which function as Adjuncts, but rather as introducing a second noun as a potential headword, or as forming double-headed nominal groups which are generally part of the specialised vocabulary generally used in a given field of research.

other Circumstantials, mainly Matter and Angle. There are some rare instances of Role and Manner/Quality. In these latter types of Circumstantials, percentages are so low, mostly of the order of 1%, that it was neither helpful nor practical for the purposes of the present analysis to distinguish yet another Conventional subcategory. It was decided to code them under Subcategory 5 because they seemed to be nearer to Matter in the kind of meanings they expressed rather than to Location or Cause and Condition Circumstantials from the other subcategories. This point will be discussed further below.

I shall start by discussing Circumstantials of Location, which have a whole subcategory to themselves, because they represent an important percentage of Contextual Frames within the present corpus.

6.3.1 Subcategory 3, Circumstantials of Location

The first subcategory within the Conventional category, Subcategory 3, comprises Halliday's Circumstancials of Extent and Location, both Extent and Location having a Spatial and a Temporal dimension (Halliday 1994:152). For Subcategory 3 I have adopted the general label of Location based on Davies' (1997) proposal for a categorisation of Circumstantial elements that draws upon Halliday's categorisation. Hence, Circumstantials expressing Location in Theory, e.g. *In Tm systems, In an astrophysical scenario*, *At the quantum level, In Equation 4,* in Discourse, e.g. *In this work, In Sec. II* , and in Time *In 1980, In recent years* will be coded under the general umbrella of Location. In the present corpus, Location Circumstantials express Location in Theory, such as *At the quantum level*, in Discourse, such as *In Sec. II,* and to a lesser extent Location in Time. Sometimes the same wordings can actually refer to slightly

different types of Location such as *At this point*, which could refer to either Theory, Discourse or Time.

However, the important point here is that all these Circumstantials of Location are expressed by very similar wordings commonly used within the genre of the research article. In the same way as Conventional Subjects, Conventional Contextual Frames of Location are part of the frequently used stock of expressions researchers have learnt to handle early on in their career as writers of research articles.

Slightly more problematic is the wording *Here*[23] which Halliday codes both as a Circumstantial of Location, more precisely of relative Location (Halliday 1994: 153, Table 5(12)), and as conjunctive element of Matter (Halliday 1994:326). Downing and Locke (1992:60) classify it as a closed-class adverb of space. In the present corpus *Here* is coded as a Conventional Contextual Frame because it is considered as expressing meanings of Location.

When there is a Typical Contextual Frame preceding a Conventional Contextual Frame, the Contextual Frame in question is coded as Conventional such as in the example *Furthermore in these terms* presented above. Throughout the present analysis, when Typical Contextual Frames accompany any other category of the Contextual Frames distinguished here, the other category takes precedence over the Typical category. The reason is that the Typical category does not take on the whole potential of

[23] Just this one word put in thematic position could lead to a number of different types of Theme analysis. If it is considered as a Circumstantial, within a Hallidayan framework it would be the Theme of the sentence. The Theme would be a marked Theme, as the writer would have chosen a Circumstance as Theme rather than the Subject. Again within a Hallidayan framework, if considered as a conjunctive element, it would then lose its Circumstantial flavour and would lead to questions as to where the Theme of the sentence would end. This just for a discussion of Theme, which in the present thesis was presented in Chapter 2. Now if we want to code Here as a Contextual Frame, how do we code it? Within the framework presented here, it would be either a 'Typical' or a 'Conventional' Contextual Frame. We have seen that there is some degree of overlap between the two in a few isolated cases, which does not affect in any drastic way my research question. Having coded *Here* as a Contextual Frame of Location, it thus belongs to 'Conventional' Contextual Frames.

the thematic wave, as Halliday and other researchers, namely Ravelli (1996) have extensively discussed.

6.3.2 Subcategory 4, Circumstantials of Cause and Condition

The second Conventional subcategory, Subcategory 4, is realised by Circumstantials of Cause and Condition. Cause, in Halliday's classification, consists either of three subcategories: Reason, Purpose and Behalf (Halliday 1994:154) when he looks more specifically at Circumstantials, or of four subcategories, Reason, Result, Purpose and Insurance (Halliday 1994: 328) when he looks at types of expansion. In my corpus causal elements are Reason and Purpose for Circumstantials, and I use the more general label of 'Cause' for these Reason and Purpose Circumstantials. I prefer to use the general label, because there are sometimes fuzzy boundaries between Reason and Purpose. Halliday's test questions for distinguishing between Reason and Purpose are the following:

Reason : *why? how?*

Purpose: *what for?* (see Table 5(15) in Halliday 1994:155)

The Contextual Frames coded as Cause in the present corpus can be seen as replying both to the Purpose-question *what for?* and to the Reason-question *why?*. Examples from the present corpus are *and for this reason, For the sake of concreteness*.

As far as the other test question for Reason, i.e. *how?*, it can be seen as highlighting rather than eliminating overlapping boundaries, this time with Manner Circumstantials. Again, because of this increasing fuzziness as one goes deeper into trying to distinguish

between more and more delicate meanings, I have preferred to use the general heading Cause.

For similar reasons I consistently use the label 'Condition' as a general heading. At first Halliday uses 'Contingency' as a general label under which he distinguishes 'Condition', 'Concession' and 'Default' (Halliday 1994:152-158). However, he then abandons the general label 'Contingency' when he goes on to discuss different types of expansion, and switches to the general label of 'Condition' under which he distinguishes 'Positive', 'Negative' and 'Concessive' (Halliday 1994: 328). In the present work the general label 'Condition' is adopted throughout, both for the corresponding Conventional Contextual Frames (non postmodified Circumstantials) and the corresponding Instantial Contextual Frames discussed below.

It is interesting to note that overlapping boundaries exist not only within Cause and Condition, but also between Cause and Condition. Halliday himself is aware of the problem, which already arises in simple prepositional phrases:

"Note that *in case of* is ambiguous (in the same way that the conjunction *in case* is ambiguous): (1) *in case of fire proceed calmly down the stairs* (2) *in case of fire refrain from smoking in bed*; the first means 'if fire breaks out', the second means 'because fire might break out'." (Halliday 1994:156, italics and parenthesis as in the original).

Halliday has chosen a particularly simple example where it is easy to see the different meanings implied by "in case of". However, as soon as one goes to an extended corpus especially of the type analysed here, it can sometimes be very difficult to pinpoint what meanings are implied at such a delicate level, more so because the categories themselves are far from water-tight.

These overlapping boundaries seem to be partly acknowledged when Halliday looks at expansion in Table 9(3) on p. 328 where the "causal-conditional" bracket could suggest a cline of meanings, with Cause sometimes extending over Condition. In the same Table 9 (3) on p. 329 (the table is spread over two pages) Halliday gives as examples of Cause-type Circumstantiation "because of", "for" and "in case of" and for Conditional-type circumstantiation "in the event of" "in default of" and "despite", with "in case of" spreading over to Condition.

Circumstantials of Cause and Condition in the Conventional Category are not very common in the present corpus, which is in agreement with Halliday's observation that

"Since the semantic relations involved in contingency [i.e. what is called Condition here - see my comment above] are typically relations between processes, they are often realised clausally …; the most usual conjunctions are *if, although, unless*" (Halliday 1994:156, square brackets added).

We shall thus come back to the expression of Cause and Condition meanings when discussing the Instantial Category.

6.3.3 Subcategory 5 Other Circumstantials without Postmodification

The third Conventional subcategory, Subcategory 5, is mainly realised by Circumstantials of Matter and Angle, and to a much lesser extent Circumstantials of Role and Manner/Quality.

In the present corpus Circumstantials of Matter are what Halliday calls 'mathematical expressions of Matter':

'Matter is related to verbal processes; it is the Circumstantial equivalent of the Verbiage, "that which is described, referred to, narrated, etc.". The interrogative is *what*

about?. Matter is expressed by prepositions such as *about, concerning, with reference to* and sometimes simply *of…*

One way of giving prominence to a Theme is to construe it as a circumstance of Matter; e.g. *as for the ghost, it hasn't been seen since*. By being first introduced Circumstantially, the ghost becomes a marked Theme … Compare mathematical expressions of Matter such as *for all x such that x > 5, …*' (Halliday 1994:157-158, italics as in the original, bold added)

Following Halliday Angle is considered here as being closely related to Matter:

'Angle is also related to verbal processes, but in this case to the Sayer; it is like "as … says". The simple preposition used in this function is *to*; but, like Matter, it is often expressed by a more complex form such as *according to, in the view/opinion of, from the standpoint of…*' (Halliday 1994:158, italics as in the original)

Examples of Circumstantials of Matter from the present corpus are *For one-dimensional problems, For hfO, For n =I*, and examples of Angle are *According to Eq. X, From Eqations (25), (43), and (46), From A 'O)*. These last two Contextual Frames, in a related way to the '*For*' Contextual Frames, are introduced Circumstantially by researchers in order to give a standpoint from which further mathematical expressions, models and theories, are constructed in a never ending quest for new results.

Examples of Role are *As Equation (X) [we take]*. Finally, expressions of quality which were not coded under the Typical Contextual Frame category, but that belong more clearly to Circumstantial expressions of Manner/Quality, such as *That way, In this way,* are also coded as belonging to the Subcategory 5 of the Conventional category.

6.4 Instantial Contextual Frames: Subcategories 6, 7, 8, and 9

6.4.1 General criteria for recognizing Instantial Contextual Frames

Instantial Contextual Frames are related to the category of Instantial Subjects in that they involve wordings which researchers have had to come up with especially, in order to steer the flow of discourse in ways which convey the meanings necessary for a text to be interpreted adequately by their peers. The fact that Instantial Contextual Frames have had to be especially crafted by writers makes them different from Conventional Contextual Frames, since Conventional Contextual Frames come from a standard stock of expressions found in research articles in physics. Another important difference between Instantial and Conventional Contextual Frames is that the former are much more difficult to code because they generally include under broad labels such as 'Cause' 'Condition[24]' or 'Means/Manner' a range of different meanings, as Davies (1997:74) found for Condition. This is partly due to the fact that Instantial Contextual Frames are not only postmodified Circumstantials, but can also be whole clauses, either finite or non-finite. Because Instantial Contextual Frames can be whole clauses, this increases the probability of their fulfilling different functions in the organisation of messages, and thus of their simultaneously comprising different types of meaning.

6.4.2 Types of meanings expressed by Instantial Contextual Frames

Instantial Contextual Frames express meanings of Cause and Condition, both worded as postmodified Circumstantials, and as finite clauses; in the case of finite clauses the type of Cause involved seems to be more frequently of the Cause/Reason and Cause/Result type. Non-finite clauses also express causal meanings, seemingly of a

[24] It has been mentioned above for the Conventional class that the label 'Condition' is consistently used as a general label rather than that of 'Contingency', and the same obviously applies for the Instantial class. As I noted for the Conventional class, at first Halliday uses 'Contingency' as a general label under which he distinguishes 'Condition', 'Concession' and 'Default' (Halliday 1994:152-158). However, he then abandons the general label 'Contingency' when he goes on to discuss different types of expansion, and

more Cause/Purpose type, and express meanings of Manner/Means as well. It should however be noted again that there are overlapping boundaries between the 'Cause' 'Condition' and 'Manner/Means' labels used by Halliday, which further complicates the coding of Instantial Contextual Frames. This was seen for instance in the Synoptic summary of expansion shown in Table 9(3) (Halliday 1994:328-329). To give yet another example, in the column on page 328 entitled 'COHESION between clause complexes (non structural)' (capitals and parenthesis as in the original), in the Manner/Means row Halliday gives as an example of a typical conjunct *Thus*. In the next row dealing with Cause, for Cause/Reason he gives as an example of conjunct *Therefore*. However, *Thus* and *Therefore* are often considered synonyms, and are the kind of conjuncts that have considerable intrinsic inbuilt meaning relatively independent from context, which indicates important overlaps in the kind of meanings each introduces.

We have suggested that there seems to be a continuum of meanings from Halliday's Cause to Condition. In the same Table 9(3), in the column on page 329 called 'CIRCUMSTANTIATION in clause (as process)' (capitals and parenthesis as in the original) the corresponding rows give *in case of* for Cause and *in the event of* for Condition, both of which again overlap in the kind of meanings expressed.

Finally, there is a multiplicity of meanings attached to the label 'Means'. For the present corpus we have suggested coding Quality/Means-type Contextual Frames as Conventional, e.g. *That way, In this way*, and coding Manner/Means-type Contextual Frames as Instantial, keeping in mind that the latter might overlap with Cause. Moreover, Manner/Means and Cause/Purpose meanings in Contextual Frame position

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switches to the general label of 'Condition' under which he distinguishes 'Positive', 'Negative' and 'Concessive' (Halliday 1994: 328), the designation adopted here.

appear to be realised mainly by non-finite clauses, (cf. above Halliday's observation that meanings of Condition tend to be realised by finite clauses).

Because of the overlapping and multiple meanings present in Instantial Contextual Frames, additional grammatical criteria can be particularly useful for coding Instantial Contextual Frames in different subcategories. This will be further developed in the next section.

6.4.3 Additional grammatical criteria for recognizing Instantial Contextual Frames

The principal types of meaning found in Instantial Contextual Frames appear to be Cause, Condition and Manner/Means, especially for clauses. The more complex and 'Instantial' the Contextual Frame, the more difficult it is to define the types of meaning involved, precisely because writers have fronted multiple and overlapping meanings. So we have two kinds of intertwined difficulties when coding Instantial Contextual Frames: those attached to the multiplicity of meanings involved, and those due to fuzzy and overlapping boundaries that can sometimes promote ambiguity in their interpretation. Ambiguity in their interpretation is of course due to the fact that the coding is made by linguists, when in fact the text is meant for a highly specialised audience of fellow physicists who do not only rely on the text per se, as linguists have to do, but on a vast amount of shared knowledge which is part of the general context within which the research is conducted.

Because of these combined difficulties it is useful to identify, as linguists, some further evidence often found in Instantial Contextual Frames, apart from the meanings involved, especially because we can sometimes find the same meanings in both the Conventional Category and the Instantial Category. Hence, meanings alone are not

enough to distinguish the two categories. What really distinguishes the two categories is how the same meaning can be expressed in different ways. So here we are looking at how the grammar can realise broadly similar meanings, but in different ways. We are looking at how authors will choose, according to their expertise, from the different resources offered by grammar to build up their texts. The various ways Instantial Contextual Frames can be realised are the following:

1 - by post-modifying Circumstantials and combining different meanings
2 - by fronting finite clauses
3 - by fronting different types of non finite clauses, either *to*-infinitive clauses or *-ing* clauses

These different ways of realising Instantial Contextual Frames are the basis for characterising the four different subcategories included within the Instantial category, Subcategories 6 to 9, which will now be presented.

6.4.4 Specific categorisation of the different Instantial subcategories

6.4.4.1 Postmodified Circumstantials of Cause and Condition and other postmodified Circumstantials: Subcategories 6 and 7

Whereas three different groups of Circumstantials without postmodification were identified in the Conventional Category, it has been necessary to distinguish only two in the Instantial Category. Circumstantials within the Instantial Category are postmodified, and are only one of the possible forms an Instantial Contextual Frame can take. Moreover, postmodified Circumstantials do not appear as frequently as those without postmodification. Examples of Subcategory 6, Postmodified Circumstantials of Cause and Condition, are the following:

Then, because of both the intrinsic mathematical interest and the potential applications of DVMs,… (Z2)

With the imposition of periodic boundary conditions,… (A2)

Due to the assumption of a linear dispersion relation in Hamiltonian (3.1),… (A2)

Examples of Subcategory 7, other postmodified Circumstantials, are the following:

In intermediate valence systems of Ce, Sm, Eu and Yb, where the magnetic susceptibility saturates…(A1)

With this procedure, and for certain values of the regularization parameter a,… (T2)

For the diffusion experiments through an unoriented LC sample within a quartz capillar,… (E3)

For a given value of the electric field F (or equivalently, of the 2D-doping concentration NZD), …

For those collisions with impact parameters b, such that at small r, R is small compared with the characteristic electron distance from the nuclei, … (P2)

These postmodifed Circumstantials tend to combine different types of meanings, giving them an 'Instantial' quality.

6.4.4.2 Dependent Finite clauses: Subcategory 8

Dependent Finite clauses in pre-Subject position, which generally express meanings of Cause and Condition, will be coded as belonging to Subcategory 8. It was noted that because the semantic relations involved in Cause and Condition were typically relations between processes, these meanings tended to be expressed clausally. Moreover, because these types of Contextual Frames are whole clauses, multiple meanings can often be involved. Examples are the following:

Since the phase depends on the transition amplitudes …

Since the phase factor describes general properties of the electron flux such as its average value and first moments, …

Although it cannot be solved for an arbitrary potential in a closed form, for a great number of usual systems in quantum mechanics …

Furthermore, if at small R the wavefunction ends up approximated by a finite combination of static molecular orbitals, …

6.4.4.3 Non-finite clauses: Subcategory 9

Non-finite clauses in pre-Subject position, which in very broad terms express meanings of Manner/Means and Cause/Purpose, will be coded as belonging to Subcategory 9. Here again coding is facilitated by having additional grammatical criteria because we are confronted with linguistic elements with a tendency to express meanings that can be ambiguous due to non-finiteness. The absence of a finite element in the verbal group implies that the proposition that is being talked about is not being given a point of reference in the here and now, and is thus not made something that can be argued about. This is because the role of the finite element is to anchor the proposition within a given context, either by reference to the time of speaking by means of primary tense, or by reference to the judgement of the speaker by means of modality (see for instance Halliday 1985, 1994: 75). Without either of these, non-finite propositions tend to be much more ambiguous that finite ones. The ambiguity often present in non-finite clauses is not only revealed when coding such clauses, but also when translating non-finite expressions: different translators often make different choices, as contrastive approaches have shown (see for instance Svensson 2000). In the present analysis, and because of the difficulties attached particularly with *ing*-type Instantial Contextual Frames (e.g. *By using Equation 7… Redefining the operator H'=Áo by shifting rb'' in the energy …* etc.) these Contextual Frames have been in general understood as expressing Manner/Means. However, one could also see them for instance as Condition, as possible rewordings could be *If we use Equation 7 … If we redefine the operator …* etc. Meanings involved in non-finite clauses such as *To set*

forth this approach …, To obtain a stable value for O would seem to fit more neatly in one niche, that of Cause/Purpose. Examples from the present corpus are the following:

To set forth this approach

To solve them

Replacing it in the Schrödinger equation, (6)

Defining it by (8)and taking into account Eq.(5),

Therefore, selecting O' to coincide at time t =0 with the centre of charge defined by z,s' - z,p' = O, q' = ZB/(ZA + ZB),

6.5 Expressive Category: Subcategories 10 and 11

6.5.1 Realisation of 'Expressive' Contextual Frames

Expressive Contextual Frames can express either interpersonal meanings per se or experiential meaning with an added interpersonal strand.

In the present corpus this added strand of interpersonal meanings is often realised by projecting clauses. Projection in Functional Grammar is seen as a relationship between elements of the phenomenal world, i.e. the projecting clause, and metaphenomena, i.e. the projected clause (Halliday 1994:249). However, whereas Halliday discusses the analysis of sentences involving projection within the framework of parataxis and hypotaxis, researchers such as Thompson (1996) and Taylor-Torsello (1996) think that projection entails a special kind of relationship between clauses, different from the more typical relations of parataxis and hypotaxis found in other clause complexes. For Taylor-Torsello (1996:162-163) projecting clauses are eminently interpersonal in that the speaker or writer is recounting, and is thus carrying out an interpersonal function. In a similar way to modality, projection is seen as a way speakers and writers have of limiting their commitment to what is being said by relating

it to a given source. One such way of limiting their commitment is of course by relating what is being said to themselves, thus giving it the status of opinion.

Thompson focuses more specifically on the difficulties of analysing Theme in sentences involving projection. To start with, this researcher mentions the difficulty in deciding whether to consider a projecting clause and its corresponding projected clause as one T-unit or two separate T-units (1996: 139). Here, as the present research analyses Theme only in main clauses, it is fairly straightforward to consider them as one T-unit.

But then there arises another, perhaps more serious difficulty: what is the main clause in the T-unit? For instance, in a sentence such as *It must be remarked that the width of n,(x, t) as a function of space grows linearly with t, namely, cr ·z vt*, in grammatical terms the main clause would be *It must be remarked*, but in semantic terms it would be *the width of n,(x, t) as a function of space grows linearly with t, namely, cr ·z vt*.

The present analysis, together with Taylor-Torsello (1996), Thompson (1996) and Davies (1997), considers not only that there a special relationship in clauses involving projection, but also that the semantic dominance of a clause prevails over grammatical dominance for the analysis of a T-unit including a projecting clause. From now on the projecting clause will thus be considered as an evaluative frame for the projected clause, and the projected clause will be considered the main clause on semantic grounds. To come back to the example presented above, *It must be remarked that* is then a Contextual Frame which precedes the main clause Subject, i.e. *the width of n,(x, t) as a function of space*.

6.5.2 Added interpersonal strands of meaning: Subcategory 10

What characterises Subcategory 10 and differentiates it from the other subcategories is that an expressive/interpersonal strand of meaning has been added to what would have originally been coded as belonging either to one of the Conventional Subcategories (Subcategories 3 to 5) or to one of the Instantial Subcategories (Subcategories 6 to 9). Hence Circumstantials, either postmodified or not, as well as any type of dependent clause in Contextual Frame position which include overtly interpersonal elements, and in particular projecting clauses, are coded as belonging to Subcategory 10 of the Expressive Category. As an example, if what would have been a Conventional Contextual Frame of Location is combined for instance with a projecting clause, it then belongs to the Expressive Category precisely because an interpersonal strand of meaning has been added in thematic position. Likewise, adding an interactive projecting clause to what would have been a plain Instantial Contextual Frame makes it part of the same Subcategory 10 of the Expressive category.

Examples are the following:
Furthermore, given a Hamiltonian H(O', we have defined a sequence of Hamiltonians IH(")], in such a way that

This is a rather peculiar system, in the sense that

Taking into account the result for the following commutators, (18) we conclude that

There are cases where the added strand of interpersonal meanings is not necessarily a projecting clause. One example is:

Obviously, if ~ is expanded over a complete basis

where the author heads with a modal Adjunct what would have been coded as a finite clause expressing conditional meanings (Subcategory 8).

Another example is the following:

In this coordinate system (really in all systems for which the centre of charge is at rest when R -,0)

Here the author has added in parenthesis a whole comment headed by *really* to *In this coordinate system* which, on its own, would have been coded as a Circumstantial of Location.

6.5.3 Projecting clauses on their own: Subcategory 11

The remainder of this section now presents different examples of Expressive Contextual Frames from Subcategory 11 .

Writers can be directly involved in Projecting clauses on their own, e.g. *We assume that, We find that*. Writers can choose to involve the reader, e.g. *Note that*. Writers can also choose 'impersonal' expressions such as *It is shown that, It can be conjectured that*. These 'impersonal' constructions can involve epithets such as *important, easy, interesting* when these epithets are part of ready made expressions such as in *It is important to note that, It is easy to see that, It is interesting to note that, It is worthwhile to stress that, It is well known that*. The constructions can also involve modals such as in *It must be remarked that*. Alternatively, writers can choose to put wordings such as *result* and *equation* into projecting clauses on their own, as in *The result is that* and *Equation (2.6a) indicates that*. The present classification does not consider that the important choice is whether the writer chooses to be visible or invisible. The important and overriding choice here is that the writer has chosen to front evaluation by means of a projecting clauses on its own. Whether it takes the form *We show that* or *It is shown that* or *Equation X shows that* the important thing here is that these different choices are

all highly interpersonal albeit in slightly different ways, and all three indicate authorial presence.

Finally there is a very small set of Contextual Frames which, because of their eminently interpersonal nature, are also coded as within Subcategory 11 of projecting clauses on their own. These represent around 1 per cent of the total set of Subcategory 11, e.g. *As is well known* (which could be reworded as *It is well known that*), and *Let…*.

If projecting clauses on their own are preceded by typically thematic conjunctions or conjunctive Adjuncts, the projecting quality of the Contextual Frame will prevail in the coding system precisely because placing *Nevertheless* or *But* in thematic position is 'Typical' and does not overrule in any way the essentially 'Expressive' nature of the Contextual Frame concerned. Hence Contextual Frames such as *Nevertheless, we see that,* and *but (we assume) that,* are coded as belonging to Subcategory 11.

Importantly, as soon as projecting clauses on their own include anything more than conjunctions or conjunctive Adjuncts, i.e. if they include added Circumstantials or, furthermore, if they are embedded in other types of thematic clauses and become of a more multifunctional nature, they will be coded within Subcategory 10 of the 'Expressive' category.

6.6 Conclusions

In conclusion to this chapter I would like to go back to an important aspect of the present taxonomy mentioned in the introduction, namely that it has to be as effective and as unambiguous as possible to show relevant statistical trends. Here I have distinguished four different categories of Contextual Frames, totalling eleven subcategories: the 'Typical' Category with Subcategories 1 and 2, the 'Conventional' Category with Subcategories 3, 4 and 5, the 'Instantial' Category with Subcategories 6,

7, 8, and 9, and the 'Expressive' Category with Subcategories 10 and 11. The Typical and Conventional Categories are comprised of more commonly used wordings within the field of research concerned, namely Adjuncts and non postmodified Circumstantials. The Instantial Category is concerned with more complex and more fashioned elements, either postmodified Circumstantials or clauses, and the Expressive category has an added interpersonal strand.

The present classification has evolved from four categories to eleven subcategories, in search of relevant replies to the present longitudinal study of writer development. It is interesting to note that the more standard Contextual Frames, i.e. in the present classification Typical and Conventional Contextual Frames, are more 'unifunctional'[25], as it were, than Instantial and Expressive Contextual Frames, which are more 'multifunctional'. Hence, the present classification has needed to acknowledge fuzzy boundaries and overlapping meanings, characteristic of Instantial and Expressive Contextual Frames. The following chapters will analyse results first on the basis of the four categories, then on the basis of the eleven subcategories, and finally on the basis of regrouping the eleven subcategories in different ways.

[25] in the sense of complying with one function and NOT in the sense of having to do with one metafunction - it should be clear at this point that Contextual Frames always involve several metafunctions, even in the case of, for instance, 'Typical' Contextual Frames which are mainly Textual, but also have a Logical flavour

PART THREE STATISTICAL ANALYSIS OF THE EXTENDED CORPUS

Chapter 7 Data collection: Selection of the extended corpus of 30 research articles

7.1 Introduction

The object of the present research is to analyse some of the changes occurring between the first and the last articles published by physicists in international journals. In order to conduct such a study, it is particularly important that the articles should be representative and provide reliable data for the linguistic analysis. The selection of the corpus thus raises important questions, such as where a corpus of the sort can be gathered, which researchers should be selected, which of their articles should be analysed and from what journals. Each one of these questions will be addressed in turn. Section 7.2 discusses the selection of the institution, Section 7.3 considers the researchers who wrote the articles, Section 7.4 the articles per se, and Section 7.5 the journals where the articles were published. The next two sections apply statistical tests to the corpus: first a test of representativity, and second a test to ensure that the data fit a Normal Distribution. Finally Section 7.8 presents the different ways in which the corpus will be analysed.

7.2 Selection of the institution

For Marshall and Rossman (1989), an institution where fieldwork is to be conducted has to satisfy the following conditions: suitable data should be available, the data should be reliable and entry should not be a problem.

In the present case, for the crucial conditions of suitability and reliability of the data to be met, the institution has to be internationally recognised on the basis of the quality of its research publications.

The third condition, entry to the institution, is especially important because of the characteristics of the present research, i.e. a longitudinal study of a group of writers of research articles. Hence, optimum entry conditions are necessary at all stages of the research. If they present problems at any stage, data will be at worst unattainable, or at best distorted and partial. In view of this, I suggest restating the very general condition 'entry to the institution should not be a problem' to the more restricted one 'the institution should offer the best possible entry conditions, considering the constraints imposed by the present research', in order to make a more informed choice amongst the existing international physics centres.

My present workplace, an internationally recognised research centre for physics and engineering in Argentina, conforms to all the conditions stated above. To quote the opening sentences from an article in the American magazine *Science* 'Staffers at Argentina's Centro Atómico Bariloche should be resting easy. The reputation of this institute for training the country's best physicists and nurturing some of its strongest basic research is secure.' (1995: 815) The article also quoted Harvard University physicists as saying that, for instance, the low-temperature physics group was 'a source of magical graduate students' (ibid.). The institution employs above one hundred researchers who publish around 300 articles in international journals each year.

For the past ten years I have held a position at the institution as a lecturer of English, both in general English and in English for Academic Purposes. Part of my work is also helping researchers edit their papers for submission to international journals. During the course of these years I have got to know numerous researchers, and have gradually become acquainted with many aspects of their work. It has been a most enjoyable and instructive ten years. Researchers have spared no time in talking about their experience in writing and publishing papers, and about their experience as referees.

The decision to collect articles written by researchers from my workplace was thus motivated not only because the institution could furnish suitable and reliable data, like many other physics centres of international repute, but also because it fulfilled the 'best possible entry' conditions. Regarding the latter, important factors were for instance having gained valuable insider information through years of work within the institution, benefiting from having members of the institution 'on line' as it were, and being able to resort to the writers themselves whenever necessary.

7.3 Selection of the researchers

Ten physicists were finally selected for the case studies. They comply with two important sets of conditions. First they are active members of their research community, producing a minimum of three international publications per year, they are regularly asked to be referees, and they supervise Ph.D. work. Second, they are the 'lone writers' of the papers selected for analysis.

As regards the first set of conditions in greater detail, all ten physicists are actively publishing and are in regular contact with a number of colleagues from other institutions and other countries. Moreover, these researchers have spent many years working in different countries, and have written and published a number of the papers from the corpus whilst they were living abroad. Of the ten researchers, one has left the institution again, this time for a permanent position as Senior Lecturer at the Imperial College in London, and one is on sabbatical leave at the UNESCO International Centre for Theoretical Physics in Trieste, Italy. Another is about to leave again, this time for a permanent position in the United States. The others are all currently participating in international projects in collaboration with France, Germany, Italy, Spain, Sweden, Mexico, the United Kingdom and the United States, amongst other countries.

Second, all ten researchers are the sole writers of each of the thirty articles selected for analysis. With respect to this second condition, clarification is needed, because in physics teamwork is the norm. Young researchers start learning the ropes of their trade in daily contact with more experienced peers. When publishing their first papers young researchers do so in conjunction with their supervisors, generally by writing parts of the paper which are then edited and often rewritten by their supervisor. Once physics students have finished their Ph.D., they generally go on to work in a research group. However, within these highly collaborative settings, there are physicists who tend to work on their own and publish on their own. Alternatively, there are physicists who do the research work in collaboration with others, but tend to be the ones who end up by writing the paper.

Henceforward an important distinction has to be made, which is particular to the remaining chapters of the present thesis. Up to now, the expressions writer and author were used as synonyms. From now on, I shall be making a clear distinction between the writer of a paper, i.e. the one who actually wrote it entirely on his/her own, and its co-authors, i.e. the researchers who by actively taking part in the research process made the writing of the final product, materialized as a paper, possible. This distinction might seem odd to linguists, but is necessary within the present framework because physics is about words and about mathematics. In physics, papers are co-authored by all the researchers who have actively participated in the research process. However, this does not necessarily mean that all the co-authors have written the actual words in the paper. The research process necessarily involves many different aspects of the work such as detailed calculations, computational and laboratory work, results under the form of equations, tables and figures, decisions to be taken about which equations, tables or figures should be presented and how they should be presented, etc. As one of my informants, working in theoretical physics, put it during an interview:

'physicists don't abandon words when it comes to describing what they are doing/ they use mathematics and they couldn't not use mathematics/ but mathematics isn't all it is either/ it is also the words/…/part of the difficulty of physics I think is precisely the whole balance between the verbal qualitative conceptual description in words/ and the mathematical precise quantitative description in terms of symbols/ hum/ well mathematical symbols because words are symbols too/…/all of us have the same problem / it's actually often easier to just derive a bunch of equations and "do equations" as it were in your research/ but that isn't actually going to relate to any

physics unless you've thought about what we call "the physics"/ and what is meant by "the physics" is a verbal conceptual description of what's going on/…' (transcription, August 22 1997 - slashes indicate pauses)

Once "the physics" has been conceptualised, then comes the actual writing stage. This explains in part why an article can be co-authored, with authors actively participating in the process, but sometimes only one of them might actually write the whole paper. The latter may be due to many different factors, ranging from personal preferences to institutional constraints. Common scenarios for physicists are having to write a paper on their own because their colleagues are travelling, or because the paper is co-authored by visiting researchers who have travelled back to their own institutions.

The reason for selecting papers written by one writer only has nothing to do with the quality of the scientific work. Physicists who tended to write on their own entire papers had to be found because of the aim of the present research, i.e. to detect changes in the writing of researchers as they gain experience. Finding these 'lone writers' was actually one of the difficulties in setting up the present study, because, as noted above, in physics working in a team is much more common than working alone.

In the event it was easier to find papers written by only one writer in theoretical physics rather than in experimental physics. Because of the very nature of experimental physics, work is generally shared out, and sometimes it actually has to be shared out because of laboratory constraints. For instance, the Methods and Results sections are sometimes written by researchers working in a given laboratory, whereas the other

sections might be written by researchers working in collaboration in other institutions, who interpret these results.

7.4 Selection of the papers

For each of the ten case studies the researcher concerned was asked to select three papers: the first he had written alone - labelled Paper 1, one of the last written alone - Paper 3, and a paper in between - Paper 2. The time span between the first and the last paper varies from 6 to 16 years, depending on the age of the researcher.

The papers have to comply with two conditions in order to be selected. The first condition is that the paper was entirely written by the researcher concerned, i.e. the researcher is not only an author but also the actual writer, and the second that it is published in an international refereed journal. Each of the ten physicists were asked to select the three papers themselves because the majority have published well over forty papers, often co-authored, and in fact the members of the research groups involved are the ones who know which papers were written by only one writer, and who the actual writer is. Moreover, the fact that ten different active members of the physics community selected the papers, rather than one linguist, increases the likelihood of the corpus being chosen at random and not concealing some hidden bias.

In the present corpus, 30 papers in all, 12 papers have as sole author the writer of the paper. The remaining 18 papers are co-authored, indicating several active participants in the research process, but were entirely written by the researcher of the corresponding case study.

For more recent papers, researchers have increasingly kept an electronic version of the paper. However, for all Papers 1 and Papers 2 no electronic version was available, and papers thus had to be scanned and passed through an Optic Character Recognition

programme. Equations and mathematical expressions in the resulting texts which were used for the analysis do not appear as in the original publication because of Optic Character Recognition constraints.

7.5 Journals where the papers were published

Physics is a highly internationalised branch of research. Publishing in physics involves several hundreds of international journals. The research articles from the corpus come from prestigious international journals mainly published by the American Physical Society, the Institute of Physics, North Holland-Elsevier Science and World Scientific Publishing Company.

For scientific journals there exists detailed information in the *Journal Citation Report* about their relative importance, and in particular, their rankings sorted by Impact Parameter. This parameter is the ratio between the number of published articles in a given journal and the number of citations referring to these articles, both within a period of two years. For instance, if a journal has an Impact Parameter of 3, this means that articles from that journal are cited in ranked international journals an average of three times within the two years following publication. The higher the Impact Parameter, the more frequently cited the articles from that journal. Figure 3 shows the relation between a given Impact Parameter and the number of physics journals with that particular Impact Parameter. The relation is an exponential one, and thus only extremely few journals - only around 20 - have an Impact Parameter of 3 or higher, whereas hundreds of them have an Impact Parameter lower than 1. Some of the articles within the present corpus have been published in journals such as *Physical Review Letter* with the highest Impact Parameter of all, i.e. 6.5, *Physical Review D* ranked 15th with an Impact Parameter of 3.6, *Journal of Physics B* ranked 29th with 2.5 and *Physica C* ranked 71st with 1.7.

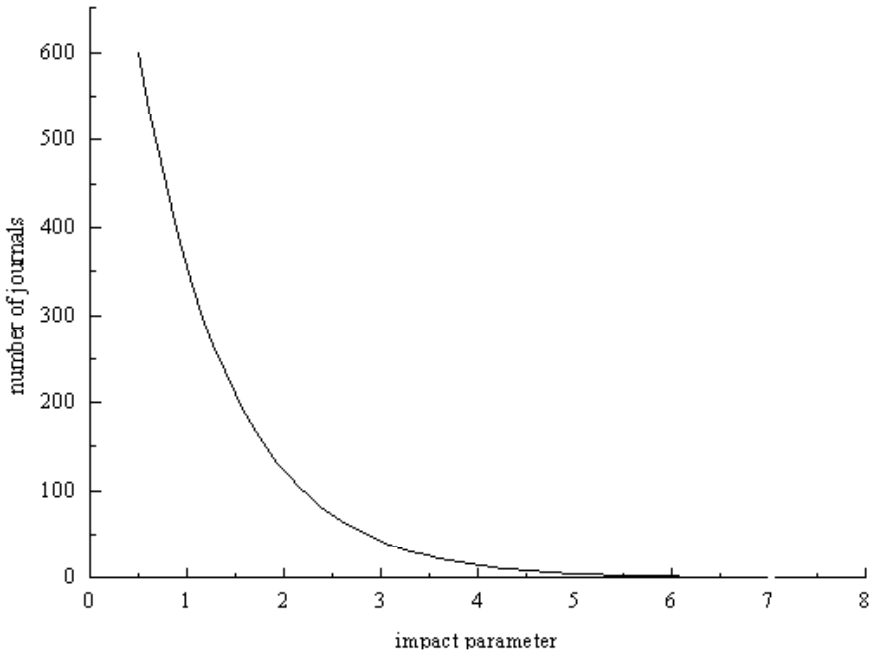


Figure 3 Number of journals as a function of their Impact Parameter

Figure 4 below shows the distribution of the articles from the present corpus as a function of the Impact Parameter, according to the journals they were published in. The sample of papers shows a Gaussian distribution which is centred around the relatively high Impact Parameter journals of around 2.9. A small number of papers come either from much higher or much lower Impact Parameter journals, indicating that in relation to the whole set of physics journals, the articles tend to come from the relatively higher ranked and more prestigious journals.

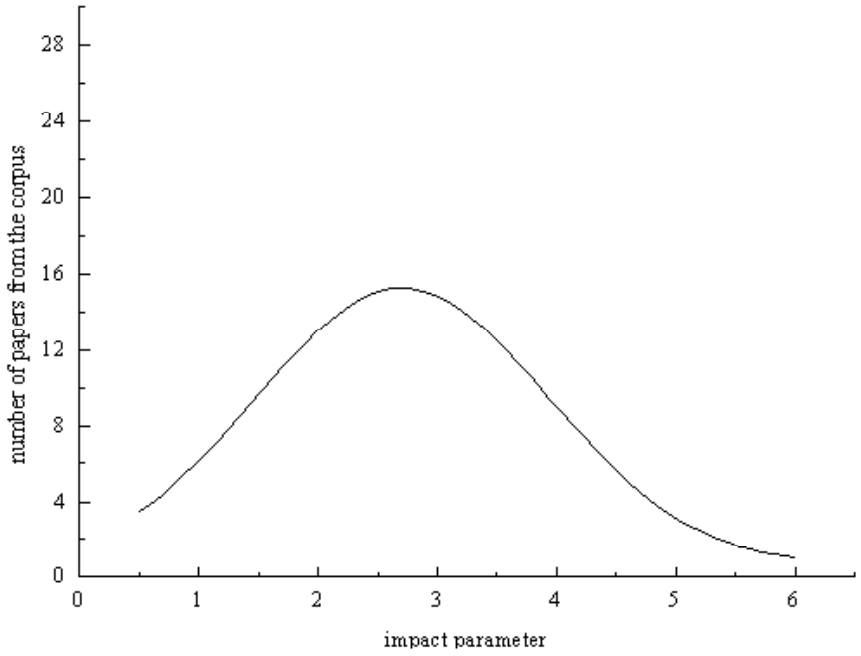


Figure 4 Articles from the present corpus as a function of their journal Impact Parameter

7.6 Testing the representativity of the sample

We saw above that all the research articles from the corpus were published in refereed international journals. But this of course is not enough to warrant they are representative of the general population of research articles. To see if they are, a statistical test has to be conducted. This further precaution is taken to make sure that the thirty articles of the present corpus are a representative sample of research articles in physics in general, especially if valid implications are to be made about the population from which they were taken. This is achieved if the sample is drawn at random from its population.

In the present case it is impossible to inspect the whole population of research articles, to say how representative the present sample is. For this reason we must resort to examining the sample itself, to make sure that the texts from the corpus do not involve some hidden trend and are truly representative. In order to do so I used the Run Test for representativity discussed for instance in Crow et al (1960). It can be easily applied and the steps taken are described in what follows.

Each one of the thirty articles from the corpus was assigned a random number going from 1 to 30 by means of a Random Number Generator. The articles were then put in order according to these random numbers. The next step was to find the mean for all thirty papers of each Subject Category percentage and of each Contextual Frame Category percentage.

For instance, in the case of Instantial Subjects, this mean value is 29.9. Once the mean is found, each paper is given a positive or a negative sign according to whether the mean is below or above the percentage for Instantial Subjects of that particular paper. Percentages less than 29.9 are marked with a minus sign and those greater than 29.9 with a plus sign. Now the interest lies in how these signs are interspersed. If the sample is random, values below 29.9 and values above 29.9 should be fairly well scattered. For example, all the low values should not precede all the high values. Neither should low values perfectly alternate with high values. If an unbroken sequence of plus signs or minus signs are computed as one 'run', for each assignation of a random sequence we have a certain number of runs. In the case of Instantial Subjects I have that all those numbers of runs thus obtained are greater than 10 and smaller than 22. Using a

table of critical values for runs (see for instance Crow 1960:244-45) this implies that my sample is a representative one with a 95% of confidence level. Put in another way, this means that the probability of my corpus being a representative sample of the general population of research articles in physics is 95%. The procedure described for Instantial Subjects was repeated for the other Subject categories and for the Contextual Frame categories, with the same confidence level.

The fact that the present corpus has a very high probability of being representative will justify my considering the whole set of results of the linguistic analysis for the ten researchers as a unique sample in a later chapter. This will provide the means for identifying and quantifying statistically significant tendencies in researchers' choices of Subject and Contextual Frame as they gain experience.

7.7 Testing whether the sample fits a Normal Distribution

In the present research there are no a priori null hypotheses, because there have been no previous statistical analyses studying changes in Subject and Contextual Frame as writers gain experience. Instead, I have propounded a set of research questions which will lead towards the construction of such assumptions. In fact null hypotheses will emerge when fitting with mathematical curves the data obtained from the extended corpus. The procedure will be the following. Data for each Subject and Contextual Frame category will be plotted, and then a curve will be adjusted through each set of data. The curve obtained for each set will represent the null hypothesis for this particular set of data.

To choose a suitable criterion to fit the data with the best possible curve we have to know what type of population the data responds to. For instance, if the data conforms to a Normal Distribution, it then becomes appropriate to use as a criterion for the goodness of the fit which is the Chi-Square minimisation. We shall come back to this later on. Our purpose at present is to test whether the data conforms to a Normal Distribution.

One possible way of checking normality can be made by using the Normal P-P Plot (or Normal Proportion-Proportion[26] Plot) available in the statistics programme SPSS. This plot represents graphically the cumulative proportion (or, in other words, the cumulative percentage) for a single numerical variable against the cumulative proportion expected if the sample were from a Normal Distribution. If the sample is in fact from a Normal Distribution, points should approximate a straight line. A Normal P-P Plot was drawn for each of the Subject and Contextual Frame categories, and for each of the eleven Contextual Frame subcategories. The plots for the four Subject categories are the following.

[26] When dealing with a sample we use the concept of Relative Frequency or Proportion, and when dealing with a population we use the theoretical equivalent of Probability, which is the probability of observations falling in a given interval or, more generally, the probability of any event out of a given set. If the sample is truly representative of the population we identify the obtained Relative Frequencies, or Proportions, for the sample with the corresponding Probabilities for the whole population.

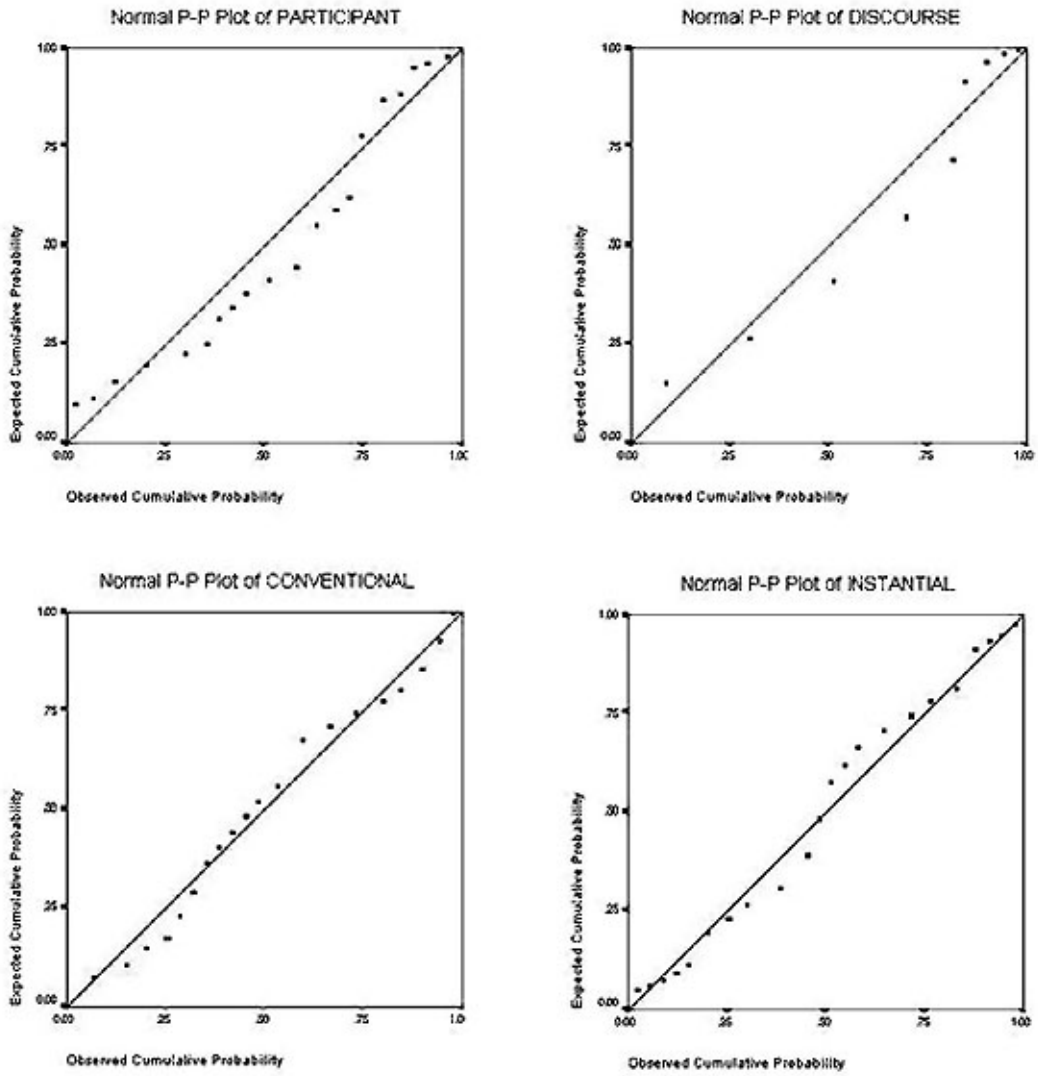


Figure 5 Normal P-P Plot for the four Subject Categories

Figure 5 shows that the sample data for each of the Subject Categories comes in fact from a Normal Distribution, because points approximate a straight line.

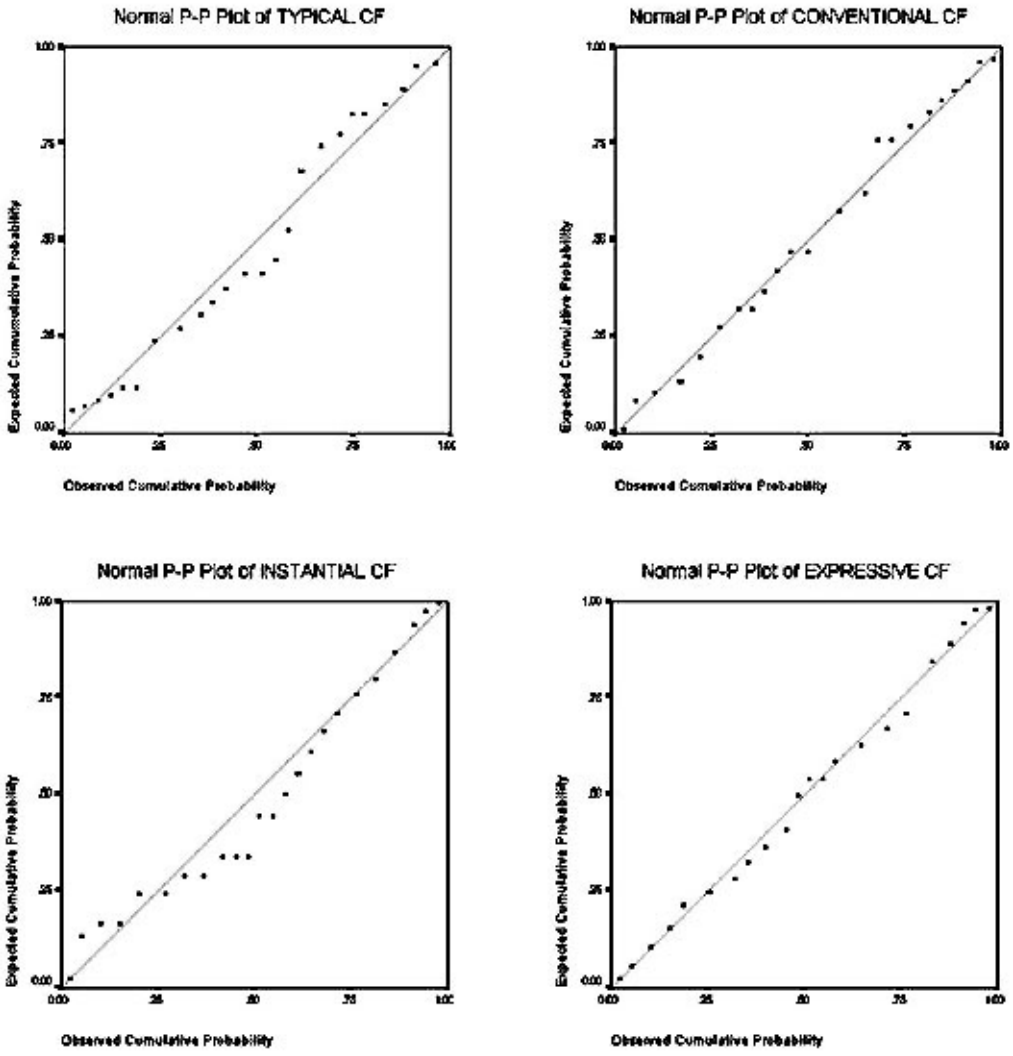


Figure 6 Normal P-P Plot for the four Contextual Frame Categories

Similarly, Figure 6 shows that the sample data for each of the four Contextual Frame Categories also comes from a Normal Distribution as points cluster along a straight line. Figure 7 overleaf shows the same tendency for the eleven Contextual Frame Subcategories.

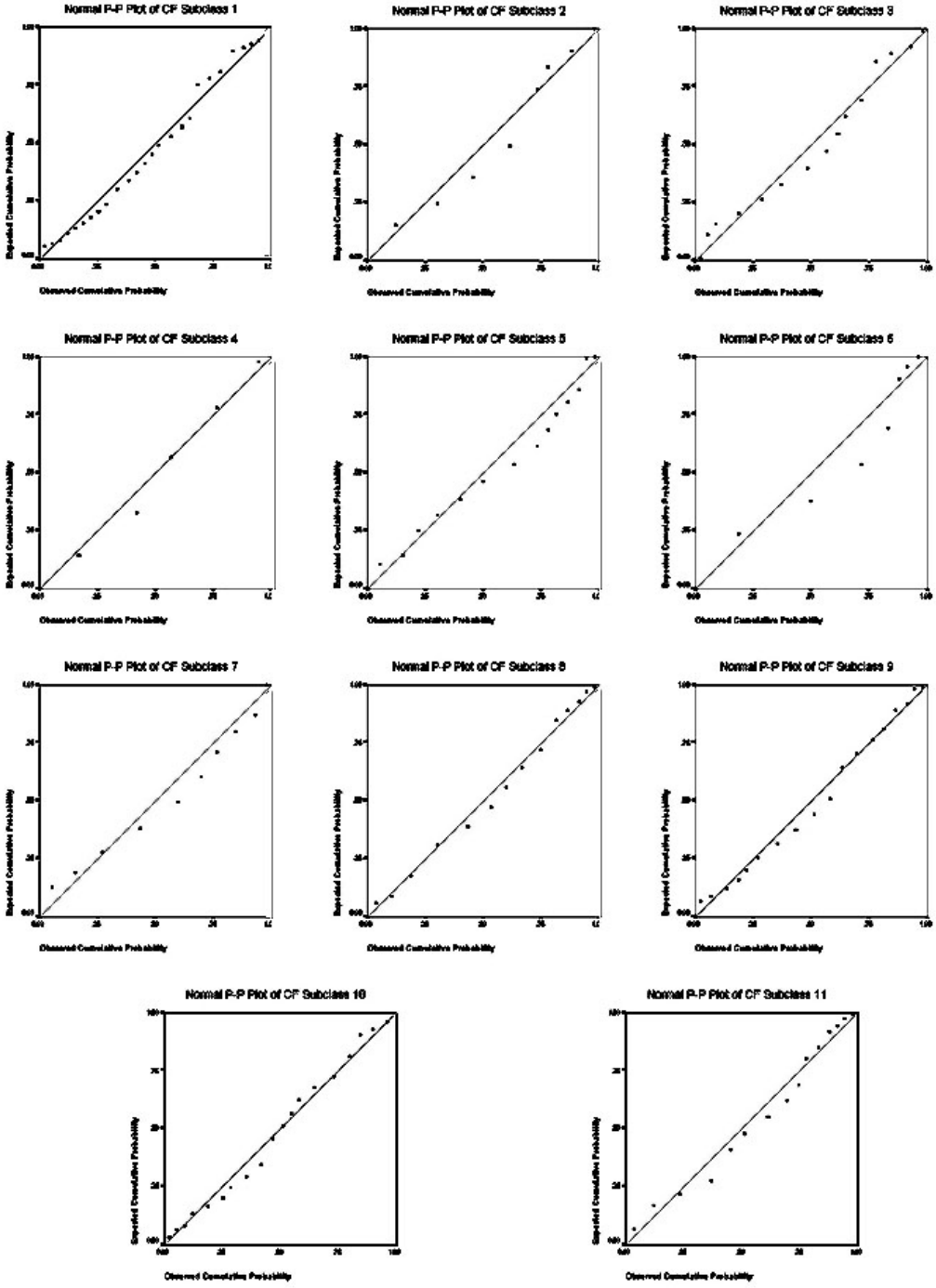


Figure 7 Normal P-P Plot for each of the eleven Contextual Frame Subcategories

Hence, as all the data in the categories and subcategories taken in turn cluster around the straight line that represents a Normal Distribution, it has become appropriate to use as a criterion for the goodness of the fit which is the Chi-Square minimisation. The smaller the Chi-square, the better the fit. This is discussed in detail in the next two chapters, where a statistical analysis of the data is presented

7.8 Conclusion

The present chapter has discussed step by step the different conditions involved in making sure the corpus provides reliable and representative data. The institution, the writers, the articles and the journals where the articles were published were examined in turn. Finally, a test measuring corpus representativity and another checking whether the data from the corpus conformed to a Normal Distribution were applied. The fact that the present corpus has a very high probability of being representative and conforms to a Normal Distribution will enable me to discuss the results of the linguistic analysis of the corpus in three different ways.

The next chapter presents the results of the linguistic analysis per Subject category. It starts by discussing each case individually, to see if the hypotheses posed for different choices of Subject hold for individual researchers as they gain experience. It will then go on to consider the total set of results of the linguistic analysis for the ten researchers as a unique sample. This will provide the means of identifying and quantifying statistically significant correlations between time and the choices made in each one of the four Subject categories which have been characterized in previous chapters. Correlations will also be explored within Subject categories. Next, the whole set of

results will again be considered as a unique sample, but this time focussing more particularly on developmental aspects, namely how choices in the different Subject categories change as researchers gain experience. A Chi-square fitting will be used throughout and its goodness of fit will be discussed for each of the four Subject categories in turn. The purpose will be to visualize statistically significant general trends, without putting emphasis on individual variations. A following chapter will present results for Contextual Frame, first focussing on the categories and then on the subcategories.

Chapter 8 Results of the Subject analysis

8.1 Introduction

As a reminder, the general purpose of the present research is to see in what ways Theme choices, understood here as comprising an obligatory Subject and an optional Contextual Frame, change as writers of Research Articles in physics gain more experience. The present chapter discusses the results for Subject choice obtained using the taxonomy presented in Chapters 4 and 5. Subject choices in the texts are coded as belonging to one of the four categories of Participant, Discourse, Conventional Phenomena and Instantial Phenomena. The less problematic categories of Participant and Discourse are as defined and illustrated in the Davies (1988) and Gosden (1996) taxonomies. On the other hand the more problematic categories of Conventional and of Instantial Phenomena are a product of the present research. The need for more objective criteria originated from coding difficulties encountered when trying to gather detailed information on the development of the command shown by writers when composing the highly specialised texts dealt with here.

The aim of the present discussion of results is to try and find replies to the research questions concerning Subject posed in Chapter 4, the general question being:

As scientists gain experience as writers, are there perceivable changes in the choice of Subjects in published research articles?

On the basis of this general research question for Subject, a further set of four more specific research questions, motivated by the way in which the pilot analysis had started to develop, was the following:

Research Question 1 - As scientists gain experience as writers, is there a move towards the selection of Subjects which have been especially fashioned to create new, experiential wordings, and which sometimes may have an added interpersonal strand, i.e. towards Instantial Phenomena Subjects?

Research Question 2 - As scientists gain experience as writers, will there be comparatively less evidence of Conventional Phenomena Subjects? More precisely, will writers be able to design the kind of experiential wordings they need by using Instantial Subjects, and thus resort less frequently to the more conventional and pre-formulated expressions typical of their field of research?

Research Question 3: As scientists gain experience as writers, will there be relatively more evidence of Participant Subjects?

Research Question 4: As scientists gain experience as writers, will there be any noticeable trends in the selection of Discourse Subjects?

Answers to the questions above will be investigated in the following ways. Section 8.2 below presents the results of the linguistic analysis for Subject on an individual basis, for each of the ten case studies. Once individual results have been examined, the next step is to look at these results grouped together as a sample of the general population of research articles. Section 8.3 takes this more general description from the point of view of possible correlations existing between changes in each Subject category and time, and between paired Subject categories. Section 8.4 explores in more detail how Subjects evolve over time, and indicates general trends for each of the four categories. Obtaining these trends, arrived at by analysing the data of a representative sample of research articles and fitting an exponential curve, will help provide further replies to the research questions above.

Appendix II-A presents the details of the Subject analysis per individual case. Appendix II-B presents the table showing the results of the Subject analysis as one sample. Appendix II-C presents the data on which the figures discussed in Section 8.4 were based.

8.2 Results of the Subject analysis for each of the ten case studies

In the following ten subsections, from Subsection 8.2.1 to 8.2.10, the distribution of Subjects in the three papers selected by each researcher in turn is presented. The letter(s) identifying each case study correspond to the researcher's surname, and the

number following the letter(s) identify the corresponding paper. For instance, A1 identifies the first paper written by Researcher A. In the bibliography, complete references are given for each paper, together with the letter and number identification system used here. There is one extra subsection, Subsection 8.2.11, which discusses two special cases: one where the researcher decreased his use of Instantial Subjects in Paper 3, and one where the researcher consistently chose to use very few Participant Subjects.

8.2.1 Researcher A

General remarks:

Researcher A works in Theoretical Physics, and more particularly in the area of Solid State Physics. The three papers the researcher selected as being a representative sample of his work and as being written by him were published in 1984 in the *Journal of Magnetism and Magnetic Materials*, in 1986 in *Physical Review B* and in 1996 in *Physica C*, with a period of twelve years between Paper 1 and Paper 3. The year span between the first and the second paper is rather short, only two years, whereas between the second and the third it is much longer, ten years. Table 20 shows the relative distribution of Subjects in the three papers.

Table 20 Distribution of Subjects in the three papers of Researcher A

Paper	Year		Participant	Discourse	Conventional Phenomena	Instantial Phenomena
1	1984	0	15%	1%	59%	25%
2	1986	2	21%	-	57%	22%
3	1996	12	15%	1%	38%	46%

We can see a peak in the selection of Subjects in the Participant Category in Paper 2, with Papers 1 and 3 exhibiting the same percentage of 15%. The Discourse Category is practically non-existent. The Conventional Category remains virtually the same in Papers 1 and 2, 59% and 57% respectively, but then abruptly diminishes between Paper 2 and Paper 3, from 57% to 38%, which replies positively to Research Question 2. Subjects in the Instantial Category present an interesting trend: their slight decrease from Paper 1 to Paper 2 does not conform with Research Question 1. However, they then more than double from Paper 2 to Paper 3 in accordance with Research Question 1. One possible explanation for these trends is that Paper 1 and Paper 2 are separated by a short period of time, where the researcher is still heavily relying on Conventional Subjects, whereas there is a much longer period of time leading up to Paper 3.

Another reason is the heavy use made by the researcher in Paper 1 of *resulting* and *observed* . Table 21 shows all the Subjects containing the words *resulting* or *observed* in Paper 1.

Table 21 Subjects containing the words 'resulting' or 'observed' in Paper 1

Paper 1	
Subjects	Wordings
1	the resulting 4f density of states in the limit of infinite 4f intra-atomic Coulomb repulsion
2	The resulting magnetic susceptibility
3	The resulting density of states
4	The resulting reciprocal magnetic susceptibility for different values of d, VP 0.1W and n I 1 (corresponding to the stoichiometric compound)
5	The resulting specific heat for the stoichiometric compound (n P 1)
6	The observed phase transition in TmSe
7	The observed Schottky anomaly in TmSe
8	The resulting reciprocal magnetic susceptibility
9	the observed absolute value
10	The greater degeneracy with respect to our model and Kondo-like effects resulting from spin-flip

All these Subjects were coded as Instantial because of the quasi clause-like flavour which adjectives such as 'resulting' or 'observed' give to a Subject: the epithets *resulting* and *observed* indicate authorial presence, and can be reworded, for instance, as *which results from…*and *we observe*. This is why their presence changes a clearly Conventional Phenomena Subject, such as *magnetic susceptibility* (Subject 2 of Table 21) or *density of state* (Subject 3 of. Table 21) from Conventional to Instantial. However, if we consider Conventional and Instantial Subjects along a cline, these types of Subject would be relatively less Instantial and nearer to Conventional Phenomena. Of the ten Instantial Subjects containing *resulting* or *observed* shown in Table 21, only three, i.e. Subjects 1, 4 and 10, would have been coded as Instantial Phenomena if *resulting* or *observed* had not been present. The other seven Subjects, representing more than 3% of the total number of Subjects in Paper 1, would otherwise have been coded as Conventional, in which case Paper 1 would have had only 22% of Instantial Subjects, the same percent as Paper 2. In Papers 2 and 3 the researcher virtually ceases using these words, or if he does they are within expressions that are anyhow heavily Instantial, such as *the only discrepancy with the observed results significantly larger than the statistical error….*

We saw above that Papers 1 and 2 are separated by a very short period of time. We have also just seen that there is a change in Researcher A's use of the epithets *resulting* and *observed*, which initially increased the percentage of Instantial Subjects in Paper 1 by 3%. Both these aspects contribute to the slight decrease in Instantial Subjects from Papers 1 to 2. Moreover, this slight decrease is followed by a noticeable increase from Papers 2 to 3, giving a clear indication of an increase in the overall trend of Researcher A's use of Instantial Subjects.

8.2.2 Researcher E

General remarks:

Researcher E works in Experimental Physics, in Optics. The three papers the researcher chose as representing his work and as being written by him were published in 1990 in *ICTPS - World Scientific*, in 1996 in *Physical Review B*, and 1999 in *Physical Review E*, with a period of nine years between Paper 1 and Paper 3. In this second case, the period of time elapsing between the first and the second paper is longer than between the second and the third, six and three years respectively. Table 22 shows the relative distribution of Subjects in the three papers.

Table 22 Distribution of Subjects in the three papers of Researcher E

Paper	Year		Participant	Discourse	Conventional Phenomena	Instantial Phenomena
1	1990	0	9%	2%	65%	24%
2	1996	6	12%	3%	50%	35%
3	1999	9	10%	7%	41%	42%

We see that the percentage of Subjects in the Participant Category does not change drastically and is around 10%, with a maximum of 12% for Paper 2. Results in Paper 3 were not only written up by E, but also entirely obtained by him, thus making him the sole author of Paper 3. Nevertheless, this fact does not seem to have greatly affected his use of *we*. Subjects in the Discourse Category slowly rise from 2 to 7%, the latter representing one of the highest percentages for the present corpus and is due to the fact that the researcher refers relatively frequently to the figures in his paper in order to discuss results. Conventional Subjects consistently diminish from 65 to 41% in

accordance with Research Question 2. Conversely, Instantial Subjects consistently rise, this time in accordance with Research Question 1, and nearly double, going from 24 to 42%.

8.2.3 Researcher F

General remarks:

Researcher F works in Theoretical Physics, in the area of Elementary Particles and Fields. The three papers the researcher regarded as best exemplifying his work when writing on his own were published in 1992 in the *International Journal of Modern Physics A* in 1995 in *Progress in Theoretical Physics* and in 1998 in *Nuclear Physics B*, with a period of six years between Paper 1 and Paper 3, the shortest span within the ten case studies. Paper 2 was published exactly in the middle of the six years. Table 23 shows the relative distribution of Subjects in the three papers.

Table 23 Distribution of Subjects in the three papers of Researcher F

Paper	Year		Participant	Discourse	Conventional Phenomena	Instantial Phenomena
1	1992	0	40%	6%	36%	18%
2	1995	3	19%	1%	56%	24%
3	1998	6	31%	2%	36%	31%

Here the high initial use of Participant Subjects is interesting as it shows that putting Participant *we* in Subject position, in a similar way to putting Conventional Phenomena in that position, can be a relatively straightforward choice researchers are able to make from the start when writing papers. A direct *we* might thus not necessarily indicate researchers have decided to take open responsibility for their work and chosen to be

visible, but rather that they have chosen *we* because it is a readily available choice. I shall come back to this in the following section, where results of the analysis are discussed taking into consideration the global trends resulting from all ten case studies. Researcher F drastically changes his choices in Paper 2, where now he focuses his choices on Conventional Phenomena and drastically diminishes his use of Participant *we* Subjects. Meanwhile, the percentage of Instantial Phenomena steadily rises, in agreement with Research Question 1, and finally, in Paper 3, we can see a much more balanced picture of choices, with Participant and Instantial Phenomena representing slightly less and Conventional Phenomena slightly more than a third each of total Subjects. Finally, Researcher F reduces his choice of Subjects in the Discourse Category as he gains experience.

8.2.4 Researcher G

General remarks:

Researcher G specializes in Materials Science, principally in the area of thermodynamic properties of metals. The three papers which he considered typified his work were published in 1982 in *CALPHAD - Pergamon*, in 1994 in *Zeitshrift für Metallkunde*, where the paper got a special award for being the best paper published in the journal that year, and in 1997 in *High Temperature Materials Chemistry*, with a period of fifteen years between Paper 1 and Paper 3. In Researcher G's case, the period of time elapsing between Paper 1 and Paper 2 is much longer than between Paper 2 and Paper 3, twelve and three years respectively. Results in Paper 1 and 3 were not only written up by G, but were also entirely obtained by him, making him the sole author in

these two publications. Table 24 shows the relative distribution of Subjects in the three papers.

Table 24 Distribution of Subjects in the three papers of Researcher G

Paper	Year		Participant	Discourse	Conventional Phenomena	Instantial Phenomena
1	1982	0	9%	3%	61%	27%
2	1994	12	16%	3%	45%	36%
3	1997	15	6%	2%	51%	41%

Table 24 shows several interesting features. First of all, the fact that G is the sole author of Papers 1 and 3 has affected his choice of Subjects in the Participant Category. In both these papers, the percentage of Participant Subjects is relatively low, and in Paper 1 not a single one is worded as *I* or *we*, but systematically refers by name to other authors. In Paper 3 the percentage of Participant Subjects is even lower - as a matter of fact it is one of the lowest in the whole corpus - but this time the few that are used are worded as *we*. In Paper 2, which is co-authored, the percentage of Participant Subjects rises significantly, but is still relatively low compared to other case studies. As G chose not to appear openly at all in Paper 1, his choice of Subjects had to be made from the other two main categories, those of Conventional and Instantial Phenomena. Predictably, as Paper 1 was the first written on his own, his choice centred on Conventional Phenomena. In Paper 2, Conventional Subjects fall abruptly whilst both Participant and Instantial Subjects rise. In Paper 3, the choice he made of appearing openly infrequently, possibly because he was not only sole writer but also sole author resulted in an increase in Conventional Phenomena, together with the increase predicted by Research Question 1 in Instantial Phenomena.

The present case study illustrates again that the researchers may choose to focus more heavily either on Participant or on Conventional Phenomena . These user-friendly categories are readily accessible to researchers as soon as they start publishing: these categories are widely adopted in papers, and are simpler to apply in a wide range of contexts. In contrast, Instantial Subjects cannot just be lifted from texts as such, but because they belong to a precise context, they have to be especially composed for that context. Hence Research Question 1 which states that as researchers gain experience, they will become increasingly capable of formulating Instantial Subjects.

8.2.5 Researcher M

General remarks:

Researcher M works in Theoretical Physics, in Particles and Fields, with research interests ranging from Electrodynamics to Quantum Mechanics, and finally to Neutrino Physics. Researcher M is one of the physicists who has varied the most in his research interests throughout his career.

The three papers Researcher M chose as representing his work and as being written by him were published in 1983 in *Il Nuovo Cimento*, in 1987 in *Physical Review A*, and in 1999 in *Physical Review D*, with a period of sixteen years between Paper 1 and Paper 3. In this fifth case, the time lapse between the first and the second paper is much shorter than between the second and the third, four and twelve years respectively. Table 25 shows the relative distribution of Subjects in the three papers.

Table 25 Distribution of Subjects in the three papers of Researcher M

Paper	Year		Participant	Discourse	Conventional Phenomena	Instantial Phenomena
1	1983	0	37%	1%	43%	19%
2	1987	4	36%	3%	36%	25%
3	1999	16	15%	1%	48%	36%

The percentage of Participant Subjects diminishes very slightly between Papers 1 and 2, and then noticeably in Paper 3. The decrease noted from Paper 1 to Paper 3 goes against Research Question 3, i.e. *As scientists gain experience as writers, will there be comparatively more evidence of Participant Subject?*. The abrupt decrease of Participant in Paper 3 is accompanied by a rise in Conventional Phenomena from Paper 2 to Paper 3. This rise is not consistent either with Research Question 2, which suggests the possibility of a decrease in Conventional Subjects. However, this rise in Conventional Subjects can be explained by the fact that as the decrease in Participant was so noticeable between Papers 2 and 3, the researcher had to shift part of his new choices of Subjects from the Participant to the Conventional Category. The other part was shifted from the Participant to the Instantial Category, as suggested by Research Question 1. Moreover, his choice of Instantial Subjects rise steadily from Paper 1 to Paper 3. Finally, as in many other cases, the Discourse category is relatively unimportant, going from one to three percent, and falling back to 1%.

8.2.6 Researcher O

General remarks:

Researcher O works in Experimental Physics, in Condensed Matter, and more specifically in superconductivity and superconducting materials. The three papers selected by Researcher O were published in 1991 in *Physica C*, in 1994 in *Physical Review B*, and in 1998 in *Physical Review Letter*, with seven years between Paper 1 and Paper 3. Paper 2 was published virtually in the middle of that period, three years after Paper 1 and four years before Paper 3. Table 26 shows the relative distribution of Subjects in the three papers.

Table 26 Distribution of Subjects in the three papers of Researcher O

Paper	Year		Participant	Discourse	Conventional Phenomena	Instantial Phenomena
1	1991	0	8%	3%	55%	34%
2	1994	3	8%	3%	52%	37%
3	1998	7	8%	9%	40%	43%

Researcher O has consistently selected 8% of his Subjects from within the Participant Category in all three papers. There is no change either in the percentage of Subjects in the Discourse Category in the first two papers, but in Paper 3 this percentage rises sharply to 9%, the highest in the corpus. One explanation for the latter is the nature of the paper which heavily relies on figures. The trends for Conventional and Instantial Phenomena reply positively to Research Questions 1 and 2: as the researcher gains experience he depends less on Conventional Phenomena when writing up results

because he is able to formulate the Instantial Subjects required for expressing certain types of meaning.

8.2.7 Researcher P

General remarks:

Researcher P works in Atomic and Molecular Physics, more specifically in Atomic Collisions. The three papers chosen by P were published in 1976 in *Radiation Effects*, in 1981 in *Journal of Physics B*, and in 1991 in *Interaction of Charged Particles with Solids and Surfaces*, with a period of fifteen years between Paper 1 and Paper 3. The time lapse between the first and the second paper is much shorter (five years) than between the second and the third (ten years). Table 27 shows the relative distribution of Subjects in the three papers.

Table 27 Distribution of Subjects in the three papers of Researcher P

Paper	Year		Participant	Discourse	Conventional Phenomena	Instantial Phenomena
1	1976	0	30%	1%	52%	17%
2	1981	5	20%	-	58%	22%
3	1991	15	4%	1%	58%	37%

Researcher P's use of Participant Subjects diminishes notably from his first to his last paper. One explanation is that he is the sole writer and author in Papers 2 and 3, and chooses to select less frequently *we* in the Subject slot, a tendency which is clearly shown in Table 28.

Table 28 Distribution of Participant Subjects, showing the percentage of 'we' wordings, in the three papers of Researcher P

Paper	Year		Participant	Percentage of Participant worded as *we*
1	1976	0	30%	28%
2	1981	5	20%	16%
3	1991	15	4%	2%

Parallel to the above tendency of using 'we' less often, as Researcher P gains experience he increasingly focuses on Phenomena-type Subjects, with by far the greatest increase occurring in the Instantial Category which more than doubles from Paper 1 to Paper 3, in agreement with Research Question 1. Hence the decrease in Participant is compensated for by an Increase in Instantial Phenomena, where the author is able to include more subtle interpersonal strands, rather than using a simple '*we*' as a default option. Conventional Phenomena Subjects increase slightly from 52% in Paper 1 to 58% in Paper 2, and stay at the same percentage in Paper 3.

8.2.8 Researcher Pro

General remarks:

Researcher Pro works in Theoretical Physics, in research topics related to Condensed Matter. The three papers selected by Researcher Pro were published in 1985 in *Physics Letters*, in 1990 in *Physical Review B*, and in 1999 again in *Physical Review B*, with fourteen years between Paper 1 and Paper 3. Paper 2 was published five years after Paper 1, and nine years before Paper 3. Table 29 shows the relative distribution of Subjects in the three papers.

Table 29 Distribution of Subjects in the three papers of Researcher Pro

Paper	Year		Participant	Discourse	Conventional Phenomena	Instantial Phenomena
1	1985	0	19%	-	56%	25%
2	1990	5	14%	-	57%	29%
3	1999	14	13%	7%	47%	33%

Subjects in the Participant Category decrease from Paper 1 to Paper 2, and then the percentage stays virtually the same in Papers 2 and 3. The decrease in the more simply and overtly interpersonal Participant Category may be due to an increase in the more subtly interpersonal Instantial Category. Conventional Phenomena stays the same in the first two papers, and then diminishes in the last. Both trends in Conventional and Instantial Phenomena are in agreement with research questions 1 and 2. What is unexpected is Researcher Pro's choice of Subjects in the Discourse Category. In Papers 1 and 2 no use is made of Discourse Subjects, and then in Paper 3 their percentage reaches 7% - one of the highest percentages within the present corpus. Most of these Discourse Subjects refer to five extremely complex figures in Paper 3. In Paper 1 there are no figures, and although there are three figures in Paper 2 they are much simpler and there Researcher Pro relied on Conventional Phenomena for his choice of Subjects rather than on Discourse.

8.2.9 Researcher T

General remarks:

Researcher T works in Theoretical Physics, in Particles and Fields. Researcher T and Researcher M are the two physicists who have varied the most in their research

interests throughout their careers. One explanation is that both are among the four researchers with the longest time spans between Paper 1 and Paper 3. It is also interesting to note that both of them work in the highly theoretical area of Particles and Fields.

Researcher T's first two papers specifically deal with Quantum Field Theory. In later years this researcher has become more and more interested in the mathematical aspects of Quantum Mechanics, and consequently his latest papers - of which Paper 3 is an example - have increasingly focused on mathematics.

The papers were published in 1983 in *Nuclear Physics B*, in 1989 in *Modern Physics Letter A* and in 1998 in *Physics Letters B*, with fifteen years elapsing between Paper 1 and Paper 3. There are six years between the first and the second paper and nine years between the second and the third paper. Table 30 shows the relative distribution of Subjects in the three papers.

Table 30 Distribution of Subjects in the three papers of Researcher T

Paper	Year		Participant	Discourse	Conventional Phenomena	Instantial Phenomena
1	1983	0	40%	4%	40%	16%
2	1989	6	30%	2%	36%	32%
3	1998	15	26%	2%	49%	23%

Of the ten case studies, Researcher T is the highest user of Participant Subjects. They decrease from 40% to 26%, 26% still being one of the highest percentages for Paper 3 within the corpus. The percentage of Discourse Subjects compared to the other three categories is small; it starts off with 4% and stays at 2% in the last two papers. Conventional Phenomena decreases slightly from Paper 1 to Paper 2, and then goes

sharply up again in Paper 3, where it represents nearly half of total Subjects. The greatest surprise is in the trend shown by Instantial Subjects. These double from Paper 1 to Paper 2, going up to 32%, and then decrease noticeably to 23% in Paper 3. Of the ten case studies, Researcher T is the only one to show, as he gains experience, such a reduction in his choices of Instantial Subjects. A possible explanation for this will be discussed below in Subsection 8.2.11 where special cases are discussed.

8.2.10 Researcher Z

General remarks:

Researcher Z works in Theoretical Physics, in Statistical Mechanics. Work in this area of research is based on models for systems which can only be described in terms of statistical probabilities, because information concerning these systems is not complete. The three papers the researcher chose as representing his work and as being written by him were published in 1988 in *Physica A*, in 1993 in *Journal of Physics A*, and 1997 in *Physical Review E*, with a period of nine years between Paper 1 and Paper 3. In this tenth case, the time lapse between the first and the second paper is slightly longer than between the second and the third, five and four years respectively. Table 31 shows the relative distribution of Subject choices in the three papers.

Table 31 Distribution of Subjects in the three papers of Researcher Z

Paper	Year		Participant	Discourse	Conventional Phenomena	Instantial Phenomena
1	1988	0	8%	-	77%	15%
2	1993	5	4%	1%	61%	34%
3	1997	9	3%	8%	55%	34%

In the case of Researcher Z there are appreciable changes between Papers 1 and 2, and smaller ones between Papers 2 and 3. As regards Discourse, Researcher Z uses none in Paper 1, only 1% in Paper 2, and then greatly increases his use of such Subjects in Paper 3 to 8% - one of the highest percentages in the corpus. This can be explained by the fact that there are no figures in the first two papers, whereas there are six complex figures in the last.

The trend in Conventional Phenomena is as predicted by Research Question 2, i.e. a progressive decrease from Papers 1 to 3. Finally, in partial agreement with Research Question 1 Instantial Phenomena Subjects more than double from Paper 1 to Paper 2, and then stay at the same percentage for Paper 3.

Researcher Z's choice of Participant Subjects in the three papers is the lowest of the corpus, and decreases from eight to only 3%. Z was asked whether he had intentionally chosen very few Participant Subjects. He replied that the choice had been deliberate, as both the research and the writing of all three papers had been entirely done by him. Hence, as he was the sole author of the papers he had tried to avoid using *we* and did not want to use *I*. In view of the fact that Research Z acknowledged deliberate choices in Participant, we examine his choices of Participant Subjects in the next subsection in greater depth.

8.2.11 Discussion of two special cases

Two cases seem not to follow the general trends. The first concerns researcher T who decreases his use of Instantial Subjects in Paper 3, thus being the only exception to Research Question 1 that suggests more evidence of Instantial Subjects as writers gain experience. The second concerns Researcher Z who has the lowest percentage of Participant Subjects in all three papers.

By discussing these two special cases in greater detail, preliminary insights will be given into the many avenues opened up by attempting a developmental study of the type presented here. However, they will remain at the level of preliminary insights in order not to deviate from the purpose of this research, i.e. to seek to identify some of the linguistic choices available to writers in physics as they gain experience in publishing their work.

8.2.11.1 Researcher T's decrease in Instantial Subjects

The only exception to Research Question 1, which suggests the possibility of there being more evidence of Instantial Subjects as writers gain experience, is Researcher T's texts. A closer look was needed, and it was discovered, on the basis of further interviews conducted with Researcher T and with close colleagues of his, that of the ten case studies T is the researcher who has changed the most in his research interests throughout his career. Researcher T is now working on, and hence writing, more mathematically formalized papers than at the beginning of his career. His last paper, although still within Quantum Field Theory, is in relative terms more different from

Paper 1 than in the other case studies, and is the most mathematical within the corpus.

A possible explanation for the decrease in Researcher T's Instantial Subjects could be that his research work is now more mathematically formalized and thus, when writing it up, might not need the same proportion of highly postmodified and interactive Subjects. To explore this possibility Researcher T was asked for another of his latest papers. He said he had several published in 1998 and 1999, but these had partly been written by some of the other co-authors. He finally selected a paper published in the same year as Paper 3, with only one other co-author also writing the paper. The paper was published in the *International Journal of Modern Physics A*. Table 32 shows the percentages for Subjects in Paper 3 and in the Extra T Paper.

Table 32 Distribution of Subjects in Researcher T's Paper 3 and the Extra T Paper written with one other co-author

Paper	Year	Participant	Discourse	Conventional Phenomena	Instantial Phenomena
3	1998	26%	2%	49%	23% (15%+8%)
Extra	1998	36%	6%	36%	22% (17%+5%)

The main interest of Table 32 is that in each paper the percentage of Instantial Subjects is roughly the same, whereas choices involving the other categories of Subjects are different. This is an important finding, as it would support the claim that the percentage of Instantial Subjects would tend to be lower in more mathematically formalised papers. It would also support the claim that the different percentages in the other categories could be due in part to differences in writing styles, as the Extra T Paper was not only written by Researcher T, but also by another co-author.

Compared to Paper 3, the Extra Paper has a higher proportion of Participant and Discourse Subjects and a lower proportion of Conventional Subjects. An overwhelming proportion of Participant Subjects (34 out of 38) are worded as *we*. The relatively high percentage of Discourse choices is due to Subjects that cluster at the end of the Introduction, where details are given on each section: '*This paper is organized as follows. Section 2 deals with … Section 3 …*' etc. These differences as well as the lower proportion of Conventional Subjects in the extra paper could be explained by the fact that as Researcher T was not the only author, different choices were made and a heavier emphasis was put on Participant and Discourse rather than Conventional Subjects.

Researcher T raises interesting questions, which go beyond the scope of the present thesis. One question could be: would there be differences in the percentage of Instantial Subjects according to the type of paper concerned? More precisely, would more formalized papers, where the researcher is within a well defined theoretical context from which logical deductions are made, require fewer Instantial Subjects than more phenomenological papers? However, these questions are of another nature to that of Research Question 1. Research Question 1 suggests looking for evidence that as researchers gain experience, they get more proficient at producing the kinds of Subjects needed for certain types of non established meanings which are more difficult to express. Research Question 1 is concerned with how the researcher's handling of Instantial Subjects develops through time, and is nearer ontogenetic studies. In a series of highly formalised papers written at different times by the same researcher, Research Question 1 would still suggest looking for a relative growth of Instantial Subjects as the researcher gained more experience. The value of the percentage per se is not at issue, but how the percentage evolves through time.

To further explore this topic, I decided to see whether I could find within my case studies researchers who could provide more mathematical papers similar to those of Researcher T. Researcher M also produces mathematically formalised work where greater use is made of mathematical demonstrations. Hence, he was asked to select for analysis such a paper, here called Paper 4. This paper is particularly interesting because a younger and less experienced colleague of Researcher M, Researcher X, had participated in the research and was co-author of Paper 4. Researcher X subsequently wrote on his own a similar paper, Paper X, which was not accepted for publication. The referee rejected Paper X on the following grounds:

"The refereed paper looks more like a student's thesis … than a paper submitted to a scientific journal. I cannot understand the aim of writing endless miles of long equations while the underlying problem is rather simple … … …

It is amusing that to show the authors *[of Paper X]* explicitly how this paper should be written I can refer to a paper on the same topic in which one of the authors is the co-author too, namely,*[Paper 4]*. I don't discuss the scientific quality of the latter paper since it is not my job, but from its 18 pages … … it is completely clear what its authors can say regarding the problem in question."

The results of the analysis for Papers 3, 4 and X are presented in Table 33. As a reminder, Papers 3 and 4 were written by Researcher M and both successfully published the same year in *Physical Review D*. One of the co-authors (but not co-writer) of Paper 4 was Researcher X, who then wrote Paper X and sent it to *Physical Review D* where it was not accepted for publication.

Table 33 Distribution of Subjects in Researcher M's Paper 3 (more phenomenological), in Researcher M's Paper 4 (more mathematically formalised) and in Researcher X's unpublished Paper X

Paper	Year	Participant	Discourse	Conventional Phenomena	Instantial Phenomena
3	1999	15%	1%	48%	36%
4	1999	27%	2%	49%	22%
X	unpublished	42%	2%	40%	16%

Let us first look at Papers 3 and 4. The differences are clearly in the choices involving Participant and Instantial Phenomena, while in both papers Conventional Phenomena represents slightly fewer than half the Subjects, and Discourse is negligible. In the more phenomenological Paper 3, where researchers are making partial use of a theory that is not completely defined but is consistent with experimental results, choices focus heavily on Instantial Subjects and comparatively less on Participant. As the theoretical context is not completely defined in Paper 3, a wider and more detailed discussion is probably necessary to justify the pertinence of assumptions and results. In order to do this, Researcher M seems to have opted for managing the discussion around carefully crafted Instantial Subjects, rather than around more overt Participant Subjects.

In the more formalised Paper 4, which is within a well defined theoretical context where extensive use of mathematical demonstrations is made, Researcher M seems to need fewer Instantial Subjects to put forward his arguments and is more inclined to appear openly in the text.

Let us now compare Papers 4 and X. In the unpublished Paper X, which is within the same well defined theoretical context as Paper 4, the less experienced researcher used a markedly lower percentage of Instantial Phenomena Subjects than his more experienced colleague. As a matter of fact, it is the lowest percentage of Instantial

Subjects in the whole corpus - 2 papers for the pilot study, 30 papers for the main corpus, plus the two extra papers considered in the present section - except for the first paper of the pilot study and Researcher Z's Paper 1. This last finding would again support the claim that Instantial Subjects would increase with time.

8.2.11.2 Researcher Z's use of Participant Subjects

Z is the researcher who has the lowest percentage of Participant Subjects in all three papers. A partial explanation may be that Researcher Z tends to work alone, and that in all the three papers he had selected for analysis, he was not only the sole writer, but also the sole author. Moreover, Researcher Z acknowledged that he had deliberately striven to avoid appearing at all, and that he had finally managed to do so in his latest papers. These particulars made it interesting to look in detail into Researcher Z's scarcity of Participant Subjects. In Table 34, Table 35 and Table 36 we can see wordings in context for the Participant Subjects in each paper.

Table 34 Wordings in context for Participant Subjects in Paper 1, representing 8% of total Subjects

Participant Subjects in Paper 1			
Contextual Frame	Participant Subjects	Process	Development
In this paper	we	obtain	exact solutions for inhomogeneous systems …
	We	obtain	known solitonic solutions [9] for the case in which …
Without loss of generality,	we	consider	p(O.
	We	propose	(3.3)
and from eqs. (2.9)	we	obtain	(3.7a) (3.7b)
	We	have extended	the analysis of the discrete two-velocity model …
For this Boltzmann equation,	we	have found	similarity solitonic solutions, representing …

Table 35 Wordings in context for Participant Subjects in Paper 2, representing 4% of total Subjects

Participant Subjects in Paper 2			
Contextual Frame	Participant Subjects	Process	Development
In (2.3a),	one	recognizes	the (scaled) continuity equation.
Entering these expansions in (2.3),	one	obtains	(2.5a) (2.5b)
For i ~ 2, instead,	one	has	the hierarchy (2.6c)
In fact, combining the second of equations (2.6c) for the ith order with the first equation for the next order,	one	obtains	(2.8) for i ~ 1.
For i B 2,	one	gets	(3.3c)
In this case, from equations (2.2) and (3.1),	one	gets	(3.15)
		Consider	then a guest species X diffusing in an …

Table 36 Wordings in context for Participant Subjects in Paper 3, representing 3% of total Subjects

Participant Subjects in Paper 3			
Contextual Frame	Participant Subjects	Process	Development
In particular,	One	should be interested	in characterizing the forms of collective evolution …
		Consider	a set of N identical elements, each of them …
and, without loss of generality,		suppose	r>O.
In order to illustrate this dependence,		consider	a set of elements initially distributed at random …

In Paper 1 *we* is used only seven times. In Paper 2 Researcher Z manages to avoid *we* altogether by using mainly impersonal constructions with *one* and in Paper 3 Researcher Z disappears completely by using mainly verbs in the imperative that enjoin the reader to 'consider' and 'suppose'. It is thus interesting to see that in Researcher Z's case there is both a quantitative decrease in the use of Participant Subjects and a qualitative change in their use, going from the more overt *we*, to imperative forms directed to the reader. Researcher Z's case is important to keep in mind because he

illustrates both unusual and conscious choices in the use of Participant Subjects. In the next section I shall discuss general tendencies in the use of Participant for the whole corpus.

8.2.12 Final observations regarding individual cases

Up to now each case study has been discussed on its own. From the presentation of results for individual cases, a general picture starts emerging which will be discussed in detail in the following section. Table 37 presents a qualitative view of how the three research questions hold as regards each case study.

Table 37 A qualitative view of how Research Questions 1, 2 and 3 hold for each case study

	Research Question 1	Research Question 2	Research Question 3
Case 1 Researcher A	YES	YES	NO - no clear trend
Case 2 Researcher E	YES	YES	NO - no clear trend
Case 3 Researcher F	YES	NO	NO - no clear trend
Case 4 Researcher G	YES	Partial YES	NO - no clear trend
Case 5 Researcher M	YES	NO	NO - it decreases
Case 6 Researcher O	YES	YES	No - it stays the same
Case 7 Researcher P	YES	NO	NO - it decreases
Case 8 Researcher Pro	YES	YES	NO - it decreases
Case 9 Researcher T	NO	NO	NO - it decreases
Case 10 Researcher Z	YES	YES	NO - it decreases

Table 37 shows that Research Question 1, suggesting an increase in Instantial Phenomena Subjects, holds for all researchers except for Researcher T of Case 9. This case was further discussed above, and an explanation was offered on the basis of the analysis of two additional research articles.

Research Question 2, suggesting that there might be fewer Conventional Phenomena Subjects, holds for five researchers, Cases 1, 2, 6, 8 and 10, and holds in part for a sixth researcher, Case 4.

Regarding Research Question 3, suggesting the possibility of there being a larger number of Participant Subjects in later articles, there is no evidence of such an increase in any of the individual cases. On the contrary, for five researchers, i.e. Case 5, and Cases 7 to 10, there are decreases in the use of Participant Subjects. In particular, Researcher Z's unusually low choice of Participant Subjects was discussed in more detail, in an attempt to provide added insight for the general discussion of results in the next sections.

No clear trend in the use researchers make of Subjects in the Discourse Category emerges from the individual case studies. Moreover, percentages for the Discourse Category are consistently very low, 1% or less in nearly half of the papers. The highest percentages are between 6 and 9% and are present in only six of the 30 papers.

The present section regarding the use of Subject categories has focused on the results for researchers taken individually. The next sections will extend and complete this discussion by considering the whole set of results for the ten researchers as a unique sample to identify and quantify statistically significant tendencies. This will give more comprehensive and systematic insights into the way Subject choices change as researchers gather experience in writing their research papers.

8.3 Results of the Subject analysis considered as one sample: a look at correlations

This section and the next, outlining the use of Subject categories, extend and complete the presentation of results for individual cases. In both Sections 8.3 and 8.4 the whole set of results for the ten researchers is now considered as a unique sample, in order to identify and quantify statistically significant tendencies. This is possible because the corpus has a high statistical probability of being a representative sample of the general population of research articles in physics. Representativity was confirmed by the test for randomness of the sample discussed in the previous chapter.

The purpose of considering the whole set of results as a unique sample, with time as the independent variable, is to offer more comprehensive and systematic insights into the way Subject choices change as researchers become more experienced in writing their research papers.

The sample has the following characteristics. All first papers have been considered as starting at an initial time conventionally indicated by zero, t=0. From then on, if a paper is published two years after a first paper it is assigned the time t=2, if it is published three years after a first paper it is assigned the time t=3, and so on, regardless of the researcher. The table in Appendix B of the general appendix shows all thirty papers of the corpus organised in this way.

The present section explores the type of relationship which exists between paired variables. It comprises four subsections. The first of these presents a set of scatter diagrams for the paired variables and a table with the resulting correlation coefficients. The second highlights significant relations between time and the use of each Subject

category. The third does the same for significant relations between one Subject category and another. Finally, the last discusses the meaning of these correlation coefficients, relates them to results obtained for individual cases, and prepares for the further discussion of general trends presented in Section 8.4.

8.3.1 The correlations displayed

The table in the general Appendix provides the means for plotting a set of scatter diagrams presented in Figure 8 below. Each scatter diagram relates a particular Subject category with time (first row) and then relates Subject categories one with another (next four rows).

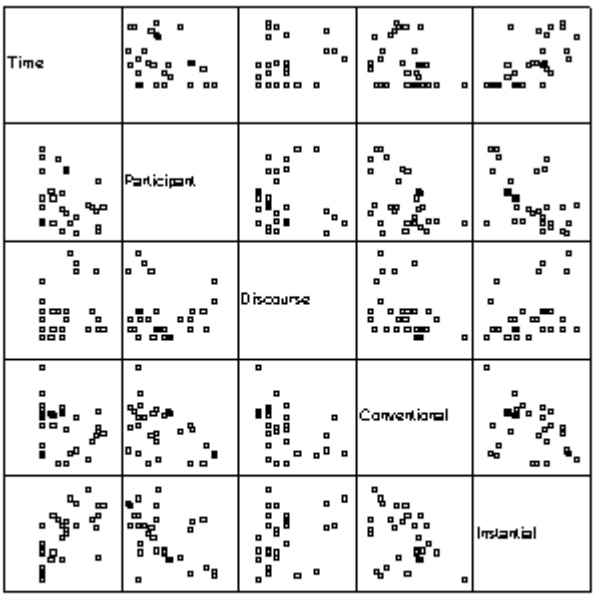


Figure 8 Scatter Diagrams

Table 38 shows the result of analysing scatter diagrams using the statistical programme SPSS, and presents a correlation coefficient for each pair of variables considered. The correlation coefficient measures the strength of the relationship between two variables. Its value goes from +1 to -1. The higher the value, the stronger the relationship between two variables. A positive sign means the variables move in the same direction, and a negative sign that if one variable increases, the other diminishes. The order is the same as in Figure 8, i.e. time with each Subject category comes first, and then one Subject category with another.

Table 38 Correlation Coefficients

		Time	Part.	Disc.	Conv.	Inst.
Time	Pearson Corr.	1.000	-.308	.180	-.266	.655(**)
	Sig. (2-tailed)	.000	.049	.171	.078	.000
	N	30	30	30	30	30
Part.	Pearson Corr.	-.308	1.000	-.075	-.460(*)	-.505(*)
	Sig. (2-tailed)	.049	.000	.346	.005	.002
	N	30	30	30	30	30
Disc.	Pearson Corr.	.180	-.075	1.000	-.419(*)	.334
	Sig. (2-tailed)	.171	.346	.000	.011	.036
	N	30	30	30	30	30
Conv.	Pearson Corr.	-.266	-.460(*)	-.419(*)	1.000	-.355
	Sig. (2-tailed)	.078	.005	.011	.000	.027
	N	30	30	30	30	30
Inst.	Pearson Corr.	.655(**)	-.505(*)	.334	-.355	1.000
	Sig. (2-tailed)	.000	.002	.036	.027	.000
	N	30	30	30	30	30
* Correlation is significant at the 0.05 level (2-tailed).						
** Correlation is significant at the 0.01 level (2-tailed).						

Table 38 marks with one or two asterisks *significant* correlation coefficients, the term *significant* being used here in its statistical sense. One asterisk indicates the correlation is significant at the 0.05 level, which means that the probability of obtaining the same result for a *non*-correlated sample of data is only 5 per cent. Thus, there is a

high probability that the sample of data is, in effect, correlated. Two asterisks indicate the correlation is significant at the 0.01 level. This is an even better correlation because the probability of obtaining the same result for a non-correlated sample becomes only 1 per cent. In consequence, the probability that the sample is correlated becomes even higher. The emphasis is always on probabilities because we are dealing with a sample coming from the much larger population of research articles as a whole.

The following subsections only discuss *significant* correlations between paired variables. First come significant correlations between time and the use of each Subject category, and next significant correlations between one Subject category and another.

8.3.2 Correlations between time and Subject categories: the Instantial-Time correlation coefficient

The first row of Figure 8 and the first main row (called Time) of Table 38 show correlation coefficient values for time paired with one Subject category in turn. There will be a statistically significant correlation if choices in a Subject category have a high probability of increasing or decreasing with time. We can see that there is one such statistically significant correlation between time and the Instantial category, of ,655. Moreover, this correlation coefficient is the only coefficient in the whole table to be marked by two asterisks, giving it the highest probability of being in effect a significant correlation. The positive sign of the coefficient means both variables move together, i.e. for longer periods of time, the use of Instantial Subjects would increase.

8.3.3 Correlations within Subject categories

The last four rows in Figure 8 show the set of scatter diagrams relating Subject categories one with another. The last four main rows in Table 38 show the corresponding results of the correlation analysis for each pair of variables considered. The value of the correlation coefficients in the table show how strongly variations in the use of one Subject category are related with variations in another category. The table shows three significant correlation coefficients marked with one asterisk, which will be discussed in turn, going from the one with the highest value to the one with the lowest. All three correlation coefficients are negative, indicating that the two variables concerned move in opposite direction. In other words, and increase in the use of one category of Subject has a high probability of bringing about a decrease in another category.

8.3.3.1 The Instantial-Participant correlation coefficient

There is a significant and negative correlation between Instantial and Participant Subjects of -,505. This means that if the percentage of one category increases, this affects the percentage of the other category which diminishes.

8.3.3.2 The Conventional-Participant correlation coefficient

There is another significant and negative correlation between Participant Subjects and, this time, Conventional Subjects of -,460. Hence if researchers use a high percentage of Conventional Subjects, it is probable they will use a low percentage of Participant Subjects. By contrast, if they use a low proportion of Conventional Subjects, it is probable they will choose to use more Participant Subjects in consequence.

8.3.3.3 The Conventional-Discourse correlation coefficient

The third and lowest significant correlation coefficient is the one relating Conventional and Discourse Subjects. It is worth -,419. The fact that it is negative means that the less frequently Conventional Subjects are used, the more Discourse Subjects will be used, and vice-versa.

8.3.4 Discussion of the correlation coefficients

8.3.4.1 Discussion of the Instantial-Time correlation

We saw that the highest and most significant correlation coefficient displayed here is the one relating Instantial Subjects with time with a value of ,655: as time passes by, there is a very high probability for Instantial Subjects to grow. This agrees with results presented in the previous section, Section 8.2, for individual cases, where nine out of

ten researchers increased their use of Instantial Subjects as they gained experience. It also confirms that the suggestion made by Research Question 1 holds not only for individual cases, but also when the data is considered as a unique sample. As a reminder, Research Question 1 suggests that as writers gain experience they will tend to use more Subjects which have been especially fashioned to create new wordings involving experiential and/or interpersonal meanings, i.e. more Instantial Subjects.

8.3.4.2 Discussion of the Instantial-Participant correlation

Of the other three significant coefficients discussed above, the second highest concerns again the Instantial category, now in relation to the Participant category, with a value of -,505. It is negative, thus indicating that changes go in opposite directions: if Instantial Subjects increase, Participant Subjects will decrease. This in fact is what is predicted by individual results which showed that with time, Instantial Subjects do tend to increase. The negative correlation coefficient between Instantial and Participant Subjects will in turn mean, albeit in a more indirect way, that Participant Subjects will decrease with time. This goes against Research Question 3 that suggests that as writers gain experience there might be comparatively more evidence of Participant Subjects. In fact, up to now, there would be comparatively less evidence of Participant Subjects according to the individual results which have been summarised in Table 37 and the present negative correlation coefficient. One explanation could be that as writers gained experience they would tend to use more subtle expressions of interpersonality attained by formulating certain types of Instantial Subjects with embedded writer presence of a more covert nature.

It is interesting to note that the correlation coefficient between Instantial and Conventional Subjects is lower, i.e. -,355, and is NOT significant at the 0.05 level. This means that the probability of Instantial and Conventional Subjects being correlated is much lower than that of Instantial and Participant Subjects. It also indirectly means that a decrease of Conventional Subjects with time considered by Research Question 2 will probably not be as strong as a decrease of Participant Subjects.

Looking at these differences in systemic terms, and more particularly in metafunctional terms, Participant has a strong Interpersonal flavour, Conventional Phenomena a strong Experiential one, and Instantial Phenomena both an Experiential and an Interpersonal flavour. Hence, as the frequency of selection of Instantial Subjects increases, it may be ventured that the Interpersonal meanings in Participant Subjects and the Experiential meanings in Conventional Subjects would both tend to flow towards the more subtle and crafted Instantial Subjects. Participant and Conventional Subjects would thus both diminish as Instantial Subjects rise. What the respective correlation coefficients suggest is that the relationship between the growth of Instantial Subjects and the decrease in Participant Subjects is stronger than the one between the growth of Instantial Subjects and the decrease in Conventional Subjects. In other words, it is more probable for Participant Subjects to diminish when Instantial Subjects rise (because the correlation coefficient is significant at the 0.05 level) than for Conventional Subjects to do so (because the value of the correlation coefficient is such that it is not significant any more at the 0.05 level).

To explain this, a claim could be made to the effect that as writers gain experience, it becomes easier for them to shift interpersonality from Participant to the more subtle Instantial Subjects. Expressing Experiential meanings in Subject position would be

more obligatory. Conventional Subjects would thus be part of the supply of more obligatory Experiential meanings present in the Research Article. How strategically these Experiential meanings are combined with Interpersonal meanings can be achieved either by using Instantial Subjects, or by using Conventional Subjects and, with experience, interweaving interpersonality in other parts of the sentence. The following section and the conclusion to this chapter will come back to these ideas.

8.3.4.3 Discussion of the Conventional-Participant correlation

As in the Instantial-Participant case, the present coefficient is negative, and the trend in the use of Conventional Subjects will move in an opposite direction to that of Participant Subjects. However, in contrast to the Instantial-Participant case, where Instantial Subjects start rising only once researchers gain experience, it has been suggested that the choice of Conventional and Participant Subjects is not a difficult or sophisticated choice to make. Researchers seem to focus their choices comparatively more on one of these two types of Subject depending on individual preferences, especially in first papers where the percentage of Instantial Subjects is still low. Some researchers might find Participant Subjects easier to manage at first, whereas others might feel more comfortable using Conventional Phenomena Subjects.

To follow with the claim posed above, as writers gain experience, they could find it cumbersome to shift most of the Experiential meanings embodied in Conventional Subjects to Instantial Subjects. They might find it easier to retain quite a few Conventional Subjects *and* increase their use of Instantial Subjects. On the other hand, it might be much easier, with experience, to shift most of the Interpersonal meanings

present in Participant Subjects to Instantial Subjects or, even, to other parts of the sentence. This again ties in with the fact that there is a stronger negative correlation coefficient between Participant and Instantial Subjects than between Conventional and Instantial Subjects: as Instantial Subjects rise, the probability of Participant Subjects decreasing accordingly is higher than that of Conventional Subjects decreasing. In other words, Participant and Instantial Subjects may be more interchangeable than Conventional and Instantial Subjects.

8.3.4.4 Discussion of the Conventional-Discourse correlation

Finally, the last and lowest significant correlation coefficient indicates opposite trends in the use of Conventional and Discourse Subjects. This should not come as a surprise, as words such as *paper* and *figure* have probably more in common with the Conventional category, than with the Participant or Instantial categories. They are conventional wordings which, while not directly referring to the phenomena under scrutiny, do refer to elaborations of those same phenomena either under the form of written text (typically referred to as *this paper…*) or under the form of tables and diagrams (typically referred to as *Table 1, Figure 1, the curve …*). Researchers might choose more Discourse-type Subjects, in which case it is probable they will need slightly fewer Conventional Phenomena Subjects in consequence. However it should also be remembered that the actual percentage values concerning Discourse Subjects are very low compared with the percentage values in the other three categories. Hence, this last correlation coefficient should be considered with greater caution than the other

three, not only because it is the lowest significant correlation coefficient, but also because of the very low values assumed by the Discourse variable itself.

8.3.5 Final remarks

In this section the relation between Subject categories and time has been examined only in a preliminary way. The relation between time and Subject categories will be looked at in greater detail in the next section. Correlation coefficients measure the strength of the relationship between two variables, if this relationship is linear. A zero correlation coefficient indicates there is no linear relationship between two variables. However, there can exist other types of more complex relations with time which are the focus of the next section.

The other significant correlations discussed here have been between paired Subject categories. These correlations have given a general background for the discussion of general trends in the use of different Subjects. We now know that there is a certain degree of interchangeability between Instantial and Participant Subjects: if the use of one of the two categories increases, it is probable that the other diminishes. Moreover, this Instantial-Participant interchangeability is significant at the statistical level, whereas it is not significant between Instantial and Conventional Subjects. We have also seen that there is a certain degree of interchangeability between Participant and Conventional Phenomena, and that it is thus probable that if Participant Subjects diminish, Conventional ones will increase. And finally, the interchangeability between Conventional and Discourse Subjects should be taken for what it is, i.e. it is statistically significant but by the weakest of the significant correlations, and more importantly involves extremely low values for the Discourse variable. As a matter of fact,

percentages representing the use of Discourse Subjects are so small compared to the other three Subject categories that they might be considered negligible later on in the research unless clear trends in their use emerge when looking in more detail at the data.

8.4 Results of the Subject analysis considered as one sample: exploring exponential relations with time

In the present section the whole set of results for the ten researchers is again considered as a unique sample to offer a comprehensive view of the ways Subject selection changes as researchers gain experience. I extend the discussion of results started in the previous section, where relationships between pairs of variables were explored in a simple way. In particular, it was found that when time was one of the variables, there was a strong relationship with Instantial Subjects. It is now time to investigate more carefully the relation between time and Subject categories.

This section is organised in six subsections as follows. Subsection 8.4.1 explains how the data will be plotted and why. Subsection 8.4.2 explains why an exponential fit was chosen, on the basis of the preliminary research questions posed above. In particular it discusses the type of assumptions arrived at on the basis of the fit. Finally, the next four subsections present results for each category in turn, with their corresponding graphical representations.

8.4.1 Presentation of the figures

There are four figures with curves showing the tendency in the use of each category of Subject in relation to time. The curves were prepared in the following way. As

described previously, the set of data from the analysis of the thirty papers by all ten writers was ordered in function of time, with t=0 adopted as a convention for the time of researchers' first publication. The table in Appendix B of the general appendix shows the corpus data organised in this way.

The total interval of time is sixteen years. The figures show seven points over this period of time. The points represent the mean value of all the data within a two-year interval, and the bars on the sides of each point represent the standard deviation corresponding to that particular mean. The standard deviation measures the scattering of the data with respect to the corresponding mean. There are seven points because within the interval covering from Year 10 to Year 12 there are no publications. The table in Appendix C of the general appendix shows the time-ordered integrated values thus obtained and on the basis of which the four figures were constructed. Each figure is discussed in a separate subsection below.

The rationale for using these points rather than just plotting all thirty dots corresponding to all thirty papers is that it provides a way of showing general tendencies common to all authors rather than individual peculiarities. The assumption is thus that each dot does not signify much on its own. Incidental variations in the use of certain types of Subjects exist, but this is not what interests us here. By taking the mean of the data obtained over two-year intervals, individual variations are moderated and it becomes easier to visualise more relevant trends. However, in order not to lose information concerning the individual variations around each one of these means, the figure also shows the standard deviation around each mean in the form of bars.

8.4.2 Research questions and data trends

8.4.2.1 Research questions

The research questions centre on the possibility of there being changes in Subject choices with the passing of time. They ask whether there might be an increase in Instantial and Participant Subjects and a decrease in Conventional ones as writers gained experience. We saw that these research questions concern the three categories that make up together more than 90% of Subjects in every single paper of the corpus. For Discourse Subjects there was both a low frequency and a lack of consistency in their use. Hence, this last research question has been left entirely open as to the kind of changes that might affect this last category.

These research questions guided us towards finding some replies when looking at changes in individual cases, and towards exploring correlations. We now need to identify and quantify statistically significant tendencies in the corpus, which can be considered as a unique sample because of its high statistical probability of being representative of the general population of research articles in physics.

The quantifiable features talked about here are the variations in percentages for each Subject category as writers gain experience. Changes are observed and analysed within the sample, and, on the basis of these observations, curves are plotted showing trends for research articles in general. These plotted curves – or statements about the values of the population parameters (e.g. Freund and Wilson 1993: 111) - will be the null hypotheses of the present research. The statistical concept of 'null hypothesis' reflects the fact that it is assumed that there is no difference between the true population

parameters and the hypothesised values, or, in other words, that the difference between the true values and the hypothesised values are nil (e.g. Koutsoyiannis 1979:562).

The identification of trends will be given by the statistical data analysis. If I ask, for instance, whether there is a possibility of Instantial Subjects increasing, this is a start, but at this stage I have been unable to describe more precisely the manner in which they may increase or what would be estimated percentages of use for first papers and estimated percentages of use for last papers.

The fitted curves representing trends will be accepted or rejected according to their resulting Chi-square. This procedure is slightly different from more common statistical procedures, where samples are drawn and analysed for the purpose of testing a given null hypothesis, which already exists, about the population (see for instance Crow et al 1960:15). In other words, it is the difference between preplanned comparisons, which are proposed before the data is collected, and post hoc comparisons, in which the data are used to propose hypotheses (Freund and Wilson 1993:253).

In the case of the present research, it has been necessary to make post hoc comparisons in order to propose hypotheses, illustrated by the best fitting curves, as there were no previous existing statistical studies providing them. The aim of what follows is to try and find for each Subject category which curve best fits the points in order to have a workable illustration of significant trends for each category.

8.4.2.2 Level of significance of the fitted curves

If the curve that best fits a set of data has a very low Chi-square value, and this curve, which illustrates the null hypothesis for a given Subject category, is accepted as being a good description of the evolution of Subject choice as writers gain experience,

the probability of accepting a correct null hypothesis, i.e. of accepting a correct description of the behaviour of this Subject category for the population as a whole, is very high. This is why in the series of figures presented in the sections below, the curve that is shown is the one found with the best possible fit, i.e. with the lowest possible Chi-square value, in order to maximise the chances of these respective curves being accepted as good descriptions of the use of each Subject category considered.

Once we have the number of points around which the curve is fitted, the corresponding degrees of freedom and the Chi-square value of the fit of the curve, one can determine its confidence level, on the basis of the Chi-square Distribution Table found in all statistics manuals (e.g. Crow et al 1960: 232-233, Koutsoyiannis 1979: 661, Freund and Wilson 1993: 607). For instance, a confidence level of 95% means that there is a 95% probability that the curve fitted through the data obtained from the sample is consistent with true values for the population, within the existing standard deviations. It is important to discuss confidence levels for each of the curves in turn. This is because in the present work, I am constructing, on the basis of data obtained from the analysis of the present corpus, curves that represent models of behaviour for the use of Subjects and Contextual Frames for the general population of research articles. Hence, it is important to know the probability of these models being good descriptors.

The purpose of the curves shown in the figures is to make it easier to visualise possible trends. The curves contribute to more detailed answers to the research questions, regarding the possible evolution of Subject categories as writers gain experience. The present research actually seeks to construct a simple and explanatory model, on the basis of data obtained when analysing the extended corpus. These data are

shown in the different figures as a series of means and their standard deviations fitted in the best possible way.

8.4.2.3 Type of fit used

In all four cases the fit was based on a decreasing exponential curve because amongst all the clearer and simpler fits, it proved to be a highly informative one considering the type of data and their behaviour. The data show increases or decreases within different categories of Subjects, and it is reasonable to suppose that these increases or decreases will tend to be greater in first papers, when young writers are forging their way ahead and still learning the 'tricks of the trade', as it were. A further reasonable assumption is to suppose that as time goes by, changes in Subject categories will tend to become smaller and smaller, reaching a minimum rate of change for expert writers who have been extensively publishing for more than a decade. Finally, it is reasonable to assume, within the context of the whole population of research articles, that none of the four Subject categories will disappear altogether, or that no Subject category will grow in such a way as to do away with any of the others. These behaviours with initially greater changes that then tend to decrease and reach a kind of plateau, are well described by decreasing exponential curves, which is the reason for choosing such fits.

8.4.3 Trends for Instantial Phenomena Subjects.

Figure 9 shows the trend in the use of Instantial Subjects in relation to time, with the seven points representing the means in the use of this type of Subject in the papers published within the two-year intervals.

We can see that in their first papers, physicists would start using around 22% of Instantial Subjects. This initial value for Instantial Subjects would gradually increase and, for periods of time longer than twelve years, would tend towards 38%. The standard deviation, given as vertical bars in the figure, measures the deviation of the actual points for a given two year period with respect to their mean value, represented by a square dot. The figure shows that standard deviations are of the order of 6%.

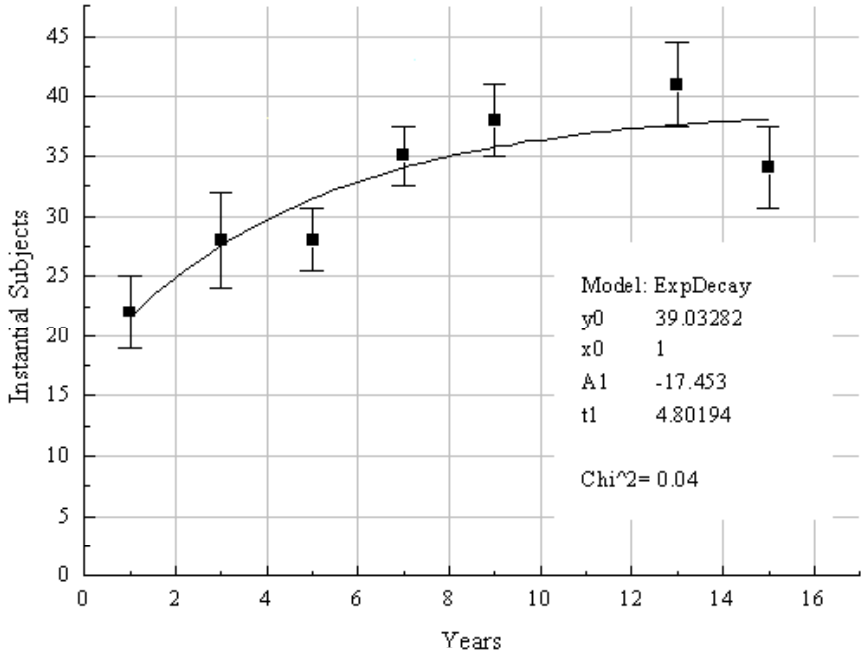


Figure 9 Trend for Instantial Subjects

The purpose here is to construct a model of the evolution of the use of Instantial Subjects, which is represented by the curve in Figure 9. An exponential curve fits extremely well the present set of data, as shown by the figure itself and measured by the

Chi-square parameter χ^2 =0.04. This Chi-square value means that the confidence level for the curve is very near 100%.

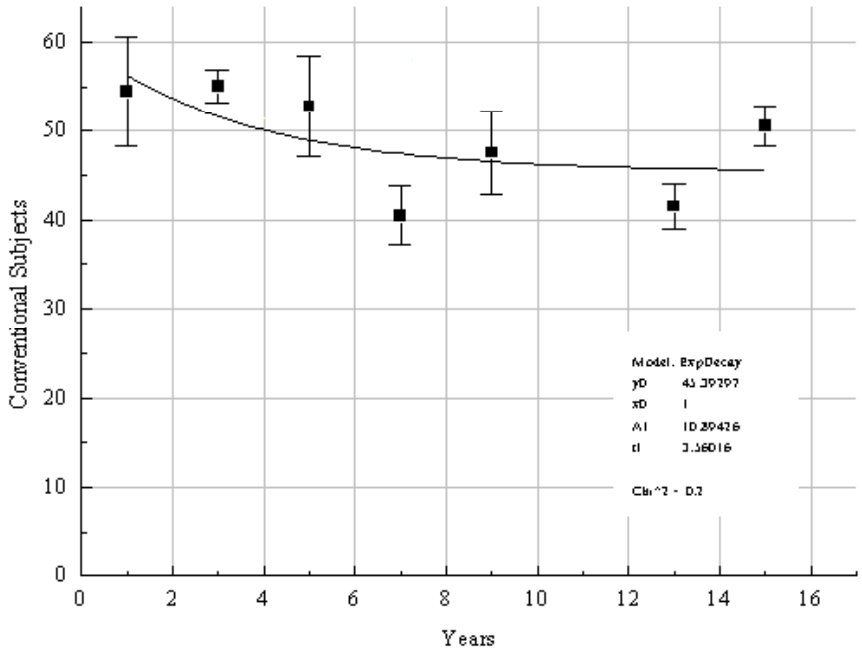
The curve shows that in the few years after writing their first paper, researchers become increasingly capable of composing the more subtle and intricate Instantial Subjects needed for arguing their case. However, there comes a point around Year 7 where the growth of these Subjects starts to slacken. This happens because of their very nature, i.e. Instantial Subjects tend to be long and often involve extensive pre and post-modification. It would probably be impossible to write a text using only such Subjects, and supposing it were possible, it would be unreadable. The trend shown here is that experienced writers tend to use slightly more than a third of the Subjects in the Instantial Category, and even considering individual variations shown by the standard deviation bars around the means, stay well under the 50 per cent level.

An interesting outcome of using an exponential fit is that it shows that in the few years immediately following an initial publication, increases in the use of Instantial Subjects are fairly important, but that these increases gradually diminish over time. This clearly points towards a maximum percentage of Instantial Subjects, after which that percentage would stay at a given level of around 38%.

8.4.4 Trends for Conventional Phenomena Subjects.

Figure 10 shows there is a tendency for Conventional Phenomena to decrease. Taking into consideration standard deviations around the means, in the first five years researchers choose between 50 and 60% of their Subjects from Conventional Phenomena. From then on, they reduce these choices to values between 40 and 50%.

Figure 10 Trend for Conventional Subjects



Again, the simplest and best fit was offered by an exponential curve, as shown by the Chi-square parameter χ^2 =0.2. This Chi-square value means that the confidence level is practically of 100%.

The trend shown in Figure 10 is for first papers to have around 55% of their Subjects in the Conventional Category, and then, as time goes by, for last papers to have

about 45% of such Subjects. Hence, later papers would tend to have about 10% fewer Conventional Subjects than first papers. The exponential fit shows that in the first four years after the first publication, there is an appreciable reduction in the use of Conventional Subjects. Reductions tend to diminish as years pass, and for periods of time longer than twelve years tend to disappear altogether. Experienced researchers will still tend to use more than 40 per cent of Conventional Phenomena Subjects. Even considering individual variations, only one paper uses just under 40 per cent of such Subjects for periods longer than 10 years.

8.4.5 Trends for Participant Subjects.

The data in Figure 11 shows means of around 20% of Participant Subjects in the first years of publishing papers, and then, in the longer term, a tendency towards the decrease in the use of such Subjects. However, the vertical bars representing standard deviations show that individual variations in the use of Participant Subjects are greater than in the case of Conventional Subjects, and much greater than in the case of Instantial Subjects.

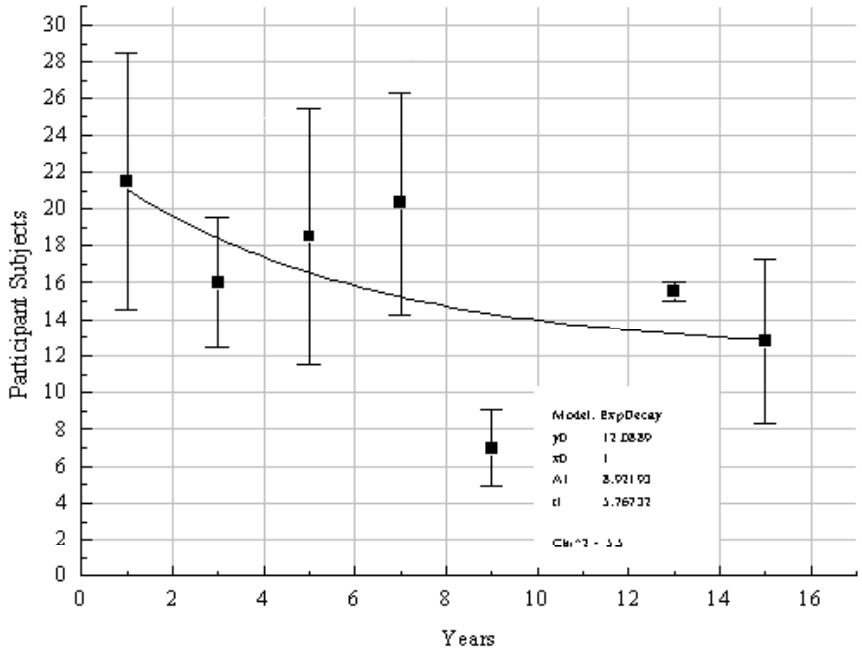


Figure 11 Trend for Participant Subjects

An exponential curve still offers the advantages of being the best fit possible considering the type of data, but the fit is not as good as in the other two cases as confirmed by the Chi-square parameter χ^2 =5.5. In fact here we have a confidence level of only 50%, which means that the fitting is not very significant.

The general trend indicated by the curve in Figure 11 is for first papers to use around 21% of Participant Subjects, whereas in later papers this percentage would tend to be around 13%. However, as the fit is not good, trends indicated for the use of Participant Subjects should be taken with greater caution. Again the exponential fit shows that in the first years there would be a greater reduction of Participant Subjects than in later years.

The exponential curve shown in Figure 11, although still the best explanatory curve available for the data, does not fit the points as well as do the previous two Subject categories because the articles in the corpus show much greater variation in the use of Participant Subjects than in Instantial or Conventional ones. Here again, and thinking along systemic lines, I would like to suggest that Participant Subjects are of a more optional nature, and reflect to a greater degree individual writer choices in the research article in Physics, than Instantial Phenomena and Conventional Phenomena Subjects. This line of argument will be pursued in the conclusion to this chapter.

8.4.6 Looking for trends in Discourse Subjects

The data in Figure 12 shows no clear trend in the use researchers make of Subjects in the Discourse Category as they gain experience, a result which had already started to show in the individual case studies. A new look at the data has confirmed the lack of a trend in the use of Discourse Subjects as time elapses.

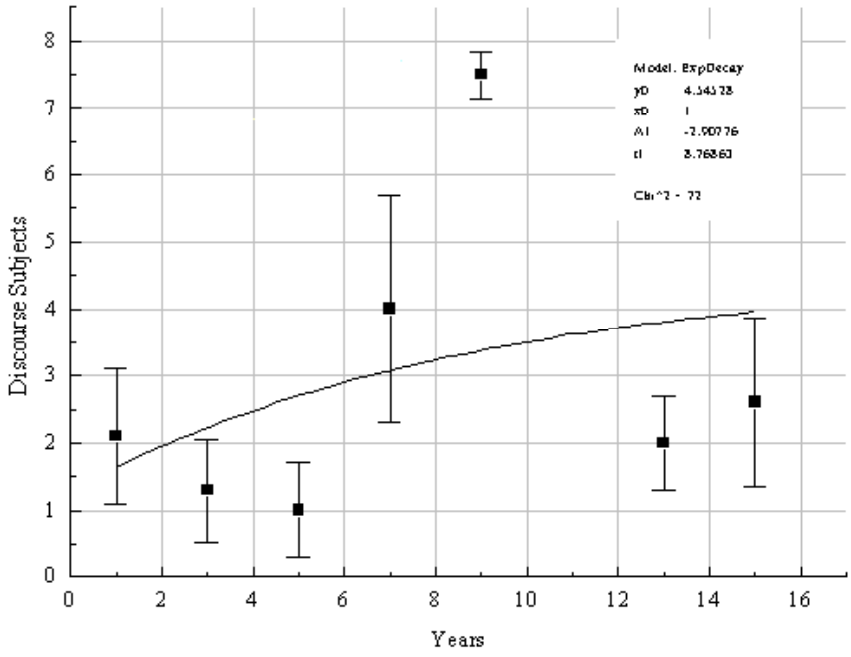


Figure 12 Trend for Discourse Subjects

For the sake of completeness a curve with the best possible fit was looked for. As expected, the fit is a very bad one, as shown by the Chi-square parameter χ^2 =72. No other explanatory curve was found showing trends that would fit the set of data in Figure 12 . Moreover, Subject percentages for the Discourse Category are consistently very low, of 1 per cent or less in nearly half of the papers. For all these reasons Discourse Subjects will be taken as a negligible category from now on.

8.5 Conclusion

We now have general trends for the three main categories of Subjects, but no satisfactory one for Discourse Subjects. Trends are shown in Figure 13. The trend for Conventional Phenomena is shown by a dashed curve, the one for Instantial Phenomena is shown by a full curve, and the one for Participant is shown by a dotted curve. For the sake of seeing how little Discourse Subjects actually count in the overall percentage of Subjects, the rather arbitrary exponential curve shown in Figure 12 is reproduced in scale at the bottom of Figure 13 but will not be further commented on because it is such a bad fit.

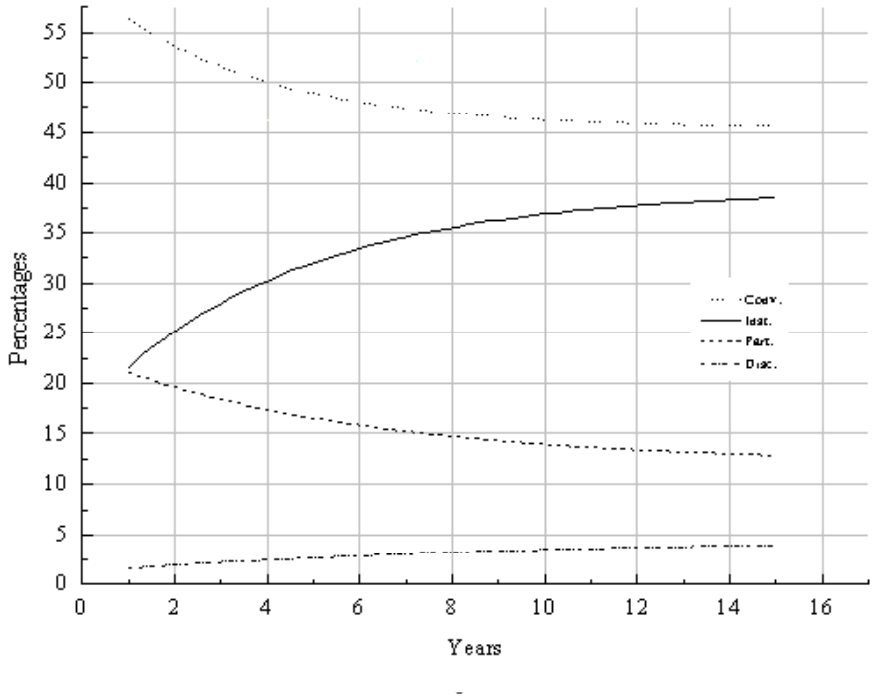


Figure 13 General trends for all four Subject categories

Figure 13 shows Conventional Subjects in general represent the most important category, and that initially it is by far the most important one representing more than half the Subjects. Instantial and Participant Subjects both start off having roughly the same percentage, around 20%. These last two categories start moving in opposite directions and very quickly take on different values, while Conventional Subjects also change and decrease, but in a less spectacular way. Six years after a first publication, fewer than half the Subjects tend to be selected from the Conventional category, Instantial Subjects are above 30%, and Participant Subjects tend to decrease to around 15%. Fourteen years after a first publication, Subjects in the Conventional Category tend to stabilise around 45%, Instantial Subjects just below 40%, and Participant Subjects just above 10%. These trends are especially significant for the Conventional and Instantial Categories. In both cases the confidence level of the fitting is nearly 100%. In the case of the Participant Category, the confidence level goes down to 50%.

The general trends described above suggest that overall, experienced researchers will probably make Subject choices from the Conventional and Instantial categories, with comparatively fewer Participant Subjects. The order for latter years would go from Conventional (highest percentage), to Instantial and finally to Participant (lowest percentage). The picture for first papers looks less tidy: Conventional Subjects would have the highest percentage, but then Instantial and Participant Subjects could start off in either order if we now bear in mind standard deviations. As Figure 14 shows, standard deviations are particularly high for Participant Subjects for first publications, and is more than 13 for t=1. This means that although the general trend signals Participant for a first paper as being around 20%, it could be, in some individual cases,

nearer 25%, in which case Participant would be the second most important type of Subject after Conventional Phenomena ones, with Instantial Subjects in third place.

Over time, Figure 14 shows standard deviations diminish noticeably for Participant and Conventional Subjects, and stay around 6 for Instantial Subjects. This signifies that individual variations around average trends tend to be much greater in the first few years of publishing than in the latter ones.

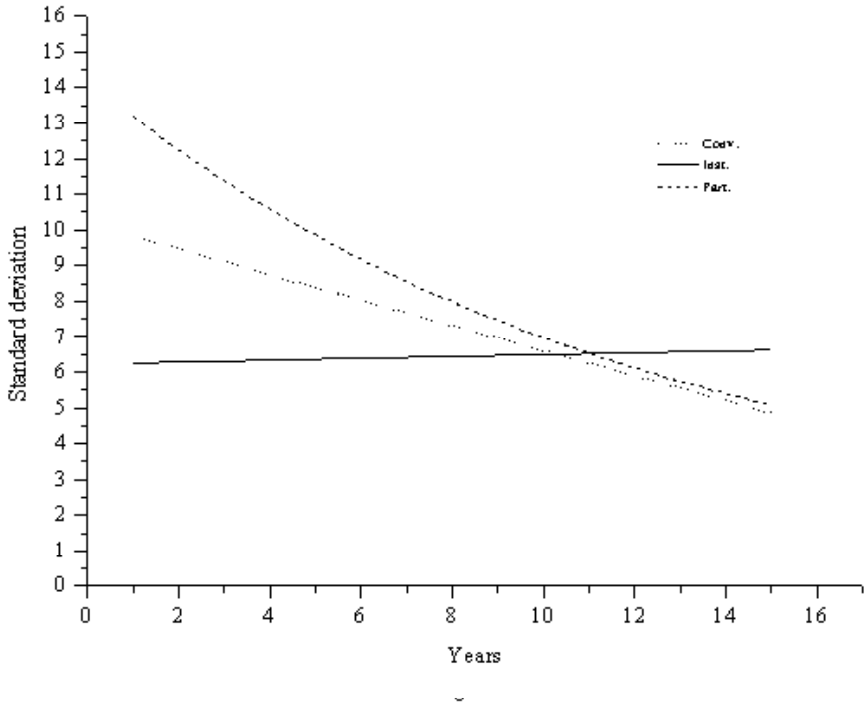


Figure 14 Evolution of the Standard Deviations of the four Subject Categories

Initially, Conventional and Participant Subjects appear to be not as difficult to use as Instantial Subjects. Researchers seem to make their choices more from one or another of these two types of Subject depending on individual preferences, especially in first papers where the percentage of Instantial Subjects is still low. Such choices, that are

partly guided by individual preferences, would explain higher standard deviations for Conventional and Participant Subjects in first papers.

Regarding Participant, choosing a comparatively high proportion of *we* might not necessarily indicate researchers have decided to take open responsibility for their work and decided to be visible. Rather, especially in first papers, they might have chosen to appear because it could be easier to organise their writing by stating *we compare…* or *we observe …* in the manner some narratives are constructed.

Regarding Conventional Subject choices, as the name of the category of course indicates, it is also a readily available option, which can be preferred to Participant, especially in later papers as it centres the flow of ideas around the phenomena being discussed. These Conventional Subjects, overall the most numerous, may be suggested as being of a more obligatory nature than Participant ones. The more optional character of Participant Subjects already surfaced in the analysis of individual cases. This optionality of Participant Subjects was even put forward as a premise for discussion above. As an illustration, we saw that some of the writers, who also happened to be the sole authors of the paper, had managed to make choices in such a way that Participant Subjects were virtually non-existent. An interesting example discussed in the corresponding section on individual cases was Researcher Z, who not only managed to reduce his use of Participant Subjects to 3%, but also managed to do away altogether with first person personal pronouns as shown in Table 36.

In contrast, and because of the very nature of the Research Article in physics, it would be virtually impossible for an author to strive to do away with Conventional Subjects. A hypothetical option could be to choose to put all the obligatory Experiential meanings needed in Subject position in the Instantial category. However, this would

prove far too cumbersome for the general flow of discourse, because of the extensive pre and post modification generally present in Instantial Subjects. Such an article, if writeable, would be unreadable.

To sum up, we would have:

Conventional Subjects - obligatory - readily available choice at the onset of publishing research articles in physics because they are part of the jargon, as it were, of the field of research concerned. Over time, it remains the category with the highest percentage although there is a tendency for them to diminish slightly.

Instantial Subjects - obligatory - more difficult Subjects to manage effectively. As time goes by and as researchers become more experienced, their relative weight nearly doubles.

Participant Subjects - optional - but a readily available choice at the onset of publishing research articles in physics. Over time, the tendency is for Participant Subjects to diminish by half.

If we now look at these general trends with Halliday's metafunctions in mind, it could be suggested that there is a tendency for Experiential meanings in Subject position to increase, with no fewer than 40 per cent of Conventional Subjects *and*, increasingly, as writers gain experience, Instantial Subjects. The tendency for Interpersonal meanings in Subject position might not be to decrease, but to be shifted from the overtly Interpersonal Participant Subjects to the more subtle and covertly Interpersonal Instantial Subjects. In general, Interpersonal meanings seems to be much more 'moveable' to different parts of the sentence. As Halliday has repeatedly pointed out, there is a tendency for Interpersonal meanings to be scattered prosodically throughout the unit, whether the unit considered is a group, a phrase, a clause or a

clause complex (see for instance 1994:190). Moreover, interpersonality covers a broad range of meanings and includes, amongst others, evaluation. By just looking at the latter, research has shown how it can adapt to different structures and move to different parts of the sentence to such an extent that 'evaluation does not have structures of its own: it is, in a sense, parasitic on other structural elements.' (Thompson 1996:65).

Chapter 9 Results of the Contextual Frame analysis

9.1 Introduction

The present chapter seeks to find replies to the research questions concerning changes in the selection of Contextual Frames as researchers gain experience in publishing their articles. Here, in contrast to Subject which is obligatory, we have two sets of choices from which writers can choose. First, due to the fact that Contextual Frame is optional, they have to choose whether to use this language slot or not. The second set of choices is the same as for Subject, i.e. if writers have chosen to use a Contextual Frame, what wording for it will they choose. I shall first discuss, in the next section, trends as authors gain experience at the first stage of choices, that of deciding to fill in the Contextual Frame slot or not, and discuss the percentage of Subjects preceded by Contextual Frames. Then, I shall go on to discuss trends as writers gain experience in the second stage of choices, those concerning the type of Contextual Frames which are chosen. This discussion aims at finding replies to the research questions concerning Contextual Frame posed in Chapter 4. There was one general question, which was:

As scientists gain experience as writers, are there perceivable changes in the choice of Contextual Frames in published research articles?

A further set of four more specific questions evolved on the basis of this general question for Contextual Frame, and on the basis of results obtained when reviewing the pilot analysis with the new Contextual Frame taxonomy. These are the following[27]:

Research Question 5 - As scientists gain experience as writers will there be relatively less evidence of Typical Contextual Frames on their own? Will experienced writers tend to fashion more complex 'Instantial' Contextual Frames with multiple strands of meaning sometimes enclosing conjunctions and conjunctive/modal Adjuncts?

Research Question 6 - Will the use of Conventional Contextual Frames remain unaltered as scientists gain experience as writers? Will a given number of these commonly used Circumstantials within particular research fields be necessary for an optimum flow of text?

Research Question 7 - As scientists gain experience as writers, will there be a move towards the use of clause-type Instantial Contextual Frames expressing multiple strands of meaning?

Research Question 8 - As scientists gain experience as writers, will there be a move towards the use of more Expressive Contextual Frames with added interpersonal strands of meaning?.

[27] The first four detailed research questions for Subject were numbered from 1 to 4. The next four detailed research questions for Contextual Frame follow immediately from this numbering, and go from 5 to 8.

Trends will be discussed for the four broad categories of Contextual Frames in Section 9.3. Once these have been examined, Section 9.4 discusses one by one results for the eleven subcategories subsequently identified, to see if more delicate and relevant trends can be observed by increasing the number of subcategories. This way of presenting results follows the steps taken when originally drawing up the new taxonomy for Contextual Frame in Chapters 4 and 6. As was noted there, when I drew up the taxonomy, I initially started by distinguishing four broad categories of Contextual Frames, namely the Typical, Conventional, Instantial and Expressive Categories. The Typical and Conventional Categories are comparatively easier to code compared with the Instantial and Expressive Categories. The easiest category to code is the Typical one, which is realised by conjunctions and Adjuncts. The next is the Conventional Category, which is realised by Circumstantials which have not been postmodified. In contrast to these first two categories, the last two categories, the Instantial and Expressive ones, are characterised by multiple strands of meaning, with the Expressive Category always having an added interpersonal strand. These categories were then made more delicate by distinguishing the eleven subcategories which will be the focus of Section 9.4. The discussion is based on the results of the statistical analysis of the corpus of 30 research articles.

Appendix II-D shows in detail the results obtained for each case study, Appendix II-E shows time ordered data used for the Contextual Frame analysis considered in four categories, Appendix II-F presents the time ordered data for the Contextual Frame analysis in eleven subcategories, Appendix II-G the integrated data used for plotting the figures for the four categories and Appendix II-H the integrated data used for plotting the figures for the eleven subcategories.

9.2 Trends in the percentage of Subjects preceded by Contextual Frames

Here we are looking at whether researchers decide to make use of the Contextual Frame slot or not. Let us recall that within a Hallidayan framework the decision to use the Contextual Frame slot can mean two things. Within this framework if the Contextual Frame contains an ideational element, it is considered as a Marked Theme. If the Contextual Frame does not contain a clearly identifiable ideational element, it then becomes part of a Multiple Theme. We saw in Chapter 2 that one of the problems with the Hallidayan framework can sometimes be deciding whether an element carries a sufficient load of ideational meanings, as it were, to warrant a clear delimitation of Theme. To solve part of the problem some systemicists such as Butt et al (1995) and McGregor (1992) have distinguished between experiential and logical meanings within the ideational, and have preferred to talk about Theme containing an identifiable experiential element. Others, such as Matthiessen and Ravelli, have adopted dynamic views of Theme where Subject is suggested as being the element that definitely uses up the whole of the thematic potential of the indicative clause. In view of the highly specialised nature of the corpus analysed here and the advantages discussed in Chapter 2 of including Subject in Theme, we adopted Davies' view of Theme, comprising an optional Contextual Frame and an obligatory Subject.

Individual trends concerning the percentage of Subjects preceded by Contextual Frames in relation to periods of time are shown in Table 39.

Table 39 Individual trends in the use of the Contextual Frame slot

Subjects preceded by a Contextual Frame	Increase from Paper 1 to Paper 3	Decrease from Paper 1 to Paper 3	No clear tendency
Case 1 Researcher A			52% - 60% - 58%
Case 2 Researcher E	28% - 47% - 58%		
Case 3 Researcher F			64% - 56% - 59%
Case 4 Researcher G	42% - 47% - 59%		
Case 5 Researcher M		76% - 67% - 60%	
Case 6 Researcher O			54% - 62% - 43%
Case 7 Researcher P		58% - 50% - 47%	
Case 8 Researcher Pro			62% - 44% - 59%
Case 9 Researcher T		60% - 54% - 54%	
Case 10 Researcher Z	46% - 58% - 61%		

The table does not show any clearly identifiable trends concerning the use of the Contextual Frame slot in time relation to time. Three researchers increase their use of Contextual Frames, three researchers decrease their use of Contextual Frames, and four researchers do not show any clear evolution in their choices.

Here we are looking at writer development, and although there is no clear individual trend towards either the increase or the decrease in the percentage of Contextual Frame slots used, when the ten case studies are examined together as one sample the percentages of use tend to be slightly less scattered in relation to time. To put this more clearly, Table 39 shows that in first papers, writers vary from using 28% to 76% of Contextual Frame slots, whereas in last papers, differences between writers narrow

down to a band going from 43% to 61% of the Contextual Frame slot being used. There does seem to be a tendency to make use of Contextual Frames within the range of roughly 50% to 60%, which would confirm the 'framing' function of Contextual Frames.

The second stage in writer choice - once the writer has actually decided to use the Contextual Frame slot – is how this slot tends to be filled in relation to time. It is this second stage in writer choice that I shall now go on to discuss, starting with an analysis of the four broad categories of Contextual Frames.

9.3 Results of the Contextual Frame analysis considered as one sample: exploring exponential relations with time for the four categories

The set of results for the whole corpus is considered as a unique sample presenting a comprehensive view of the ways Contextual Frame selection changes as researchers gain experience. To help clarify the discussion, figures illustrate average uses over two-year periods fitted by exponential curves. An exponential fitting was again chosen because it is the simplest and most illustrative way of reflecting relevant trends.

Figures 15 to 20 in the present section show the tendency in the use of each broad category of Contextual Frame over time. All the figures use the same scale for the vertical axis of 0 to 50, which indicates the percentages of a given category of Contextual Frames. The horizontal axis, as usual, represents time, with one interval per year. Each figure is discussed separately. The figures were prepared in the same way as for Subject. As described previously, the set of data from the analysis of the thirty papers by all ten writers was ordered in function of time, with t=0 adopted as a convention for the time of researchers' first publication. The table in Appendix E of the General Appendix shows the corpus data for Contextual Frame organised in this way.

The total interval of time is sixteen years. As for the analysis concerning Subjects, the figures show seven points over this period of time. The points represent the mean value of all the data within a two-year interval, and the bars on the sides of each point represent the standard deviation corresponding to that particular mean. We saw that the standard deviation measures the scattering of the data with respect to the corresponding mean. We also saw that there are seven points because within the interval covering from Year 10 to Year 12 there are no publications. The table in Appendix G of the general appendix shows the values thus obtained and on the basis of which these figures were constructed.

Once more, the rationale for using these points rather than just plotting all thirty dots corresponding to all thirty papers is that it provides a way of showing general tendencies common to all writers rather than individual peculiarities. By taking the mean of the data obtained over two-year intervals, it becomes easier to detect and eventually visualise more relevant trends. Information concerning individual variations around each one of these means is retained under the form of a standard deviation bar around each mean.

It is important to restate that the purpose of Figures 15 to 20 is to make it easier to visualise general trends. The curves in the figures constitute a simple model of the likely evolution in the use of Contextual Frames as researchers gain experience in writing their articles. As we saw for Subject, the Chi-square value measuring the goodness of the fit of the curve to the data gives a measure of the confidence level, i.e. of how probable it is for the curve fitted through the data obtained for the sample to be a valid description for the population as a whole. In a similar way to the statistical analysis for Subjects, in

all the figures an exponential curve was chosen because amongst the clearer and simpler fits, it proved to be the most informative one considering the type of data.

9.3.1 Typical Contextual Frames

Typical Contextual Frames are conjunctions and conjunctive and modal Adjuncts. As explained earlier on in this work, the name 'Typical' for this category comes from the fact that their thematic status in the clause is to be at least typically thematic, with a small sub-set of elements such as *and* & *but*, if used, being obligatorily thematic.

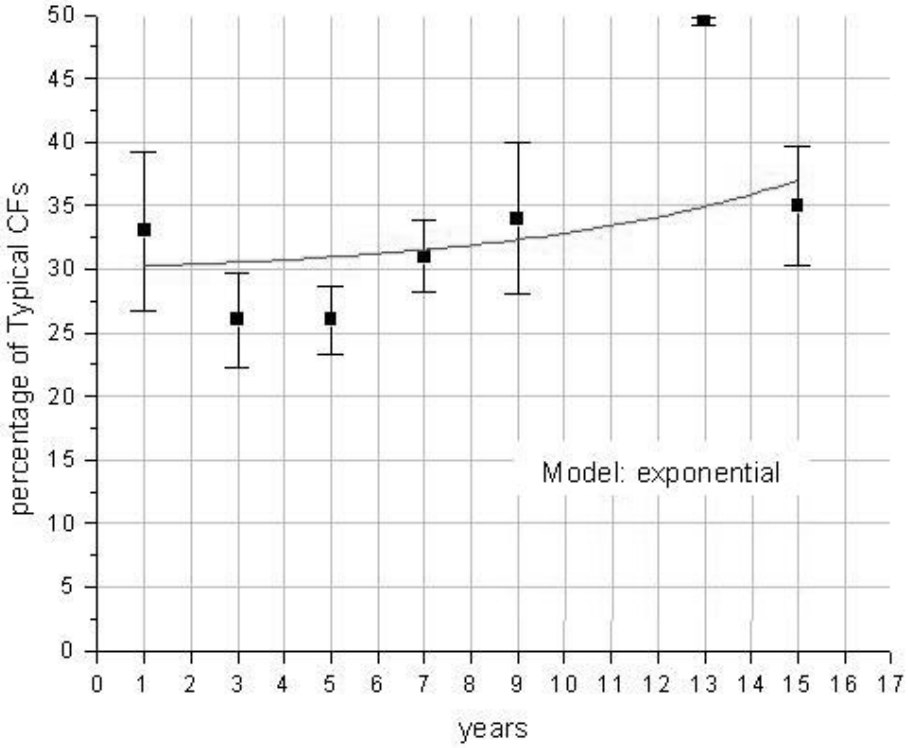


Figure 15 Fit for Typical Contextual Frames including the outlier point

Figure 15 shows the set of data for Typical Contextual Frames. In this figure the existence of a very uncharacteristic point for Year 13, distant from the general tendency and with an extremely small standard deviation is striking. This point groups together data concerning the two papers with the highest percentage of use of Typical Contextual Frames in the whole corpus. It happens to have not only very high values but also very close ones, which also indicates that it corresponds to an unrepresentative fluctuation respect to the general trend. This type of data can be considered as an 'outlier' in the statistical sense (Freund and Wilson 1993:360) and excluded from the statistical analysis once we have verified whether it affects significantly the fitting of the curve.

In order to see the type of influence this outlier has, Figure 16 considers exactly the same data but without considering Year 13. Figure 16 shows that the curve moves only very slightly downwards. The fact that the curve moves only very slightly downwards shows that in fact the unusual and extreme value shown by Year 13 exerts a relatively small influence, or leverage, on the actual trend shown by this curve. This in turn indicates that the omission of Year 13 is justified considering that we are exploring possible trends (Freund and Wilson 1993: 365). The indicated trend is for writers to increase their use of Typical Contextual Frames by about 7% over the years, starting at around or just below 30% in first papers, with a Chi-square of 0.02 indicating a very good fit nearing the 100% confidence level.

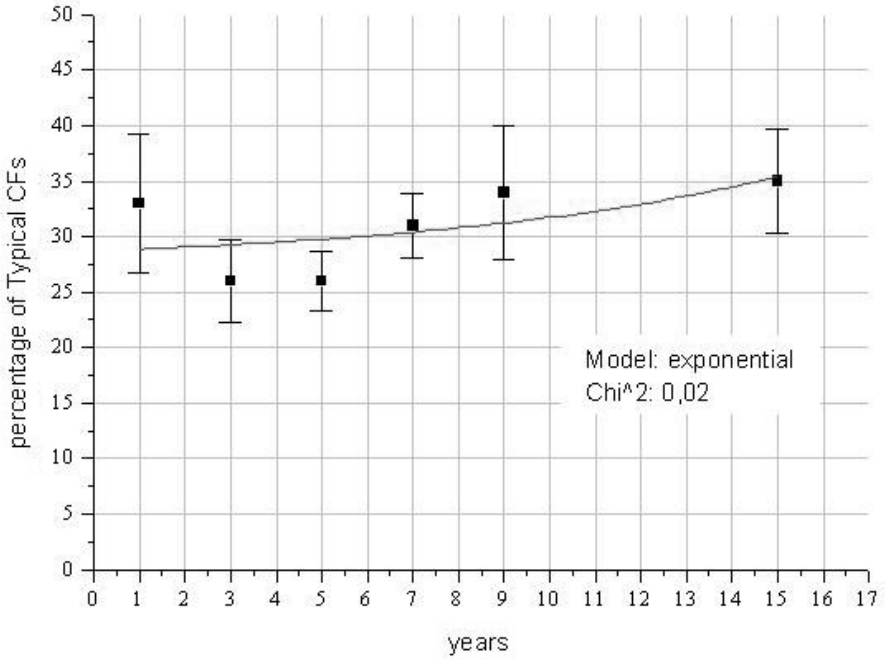


Figure 16 Trend for Typical Contextual Frames

In order to investigate in greater detail this trend, which is actually opposite to the one shown in the pilot study, the Typical Category will be looked at in more detail with Subcategory 1 comprised of conjunctions and conjunctive Adjuncts, and Subcategory 2 of modal Adjuncts.

9.3.2 Conventional Contextual Frames

Conventional Contextual Frames were characterised as Circumstantials which can be pre-modified, but not postmodified except certain 'of-type' nominal groups (Sinclair 1991). Moreover, Conventional Contextual Frames were identified as sometimes being worded by means of the referring - or naming - type of grammatical metaphor (Halliday 1998: 195). This type of taxonomising grammatical metaphor operates by means of

pre-modified nominal groups and become a feature of 'the semi-designed registers of technology and science' (Halliday 1998:197) which forms part of the specialised language of the field of research concerned.

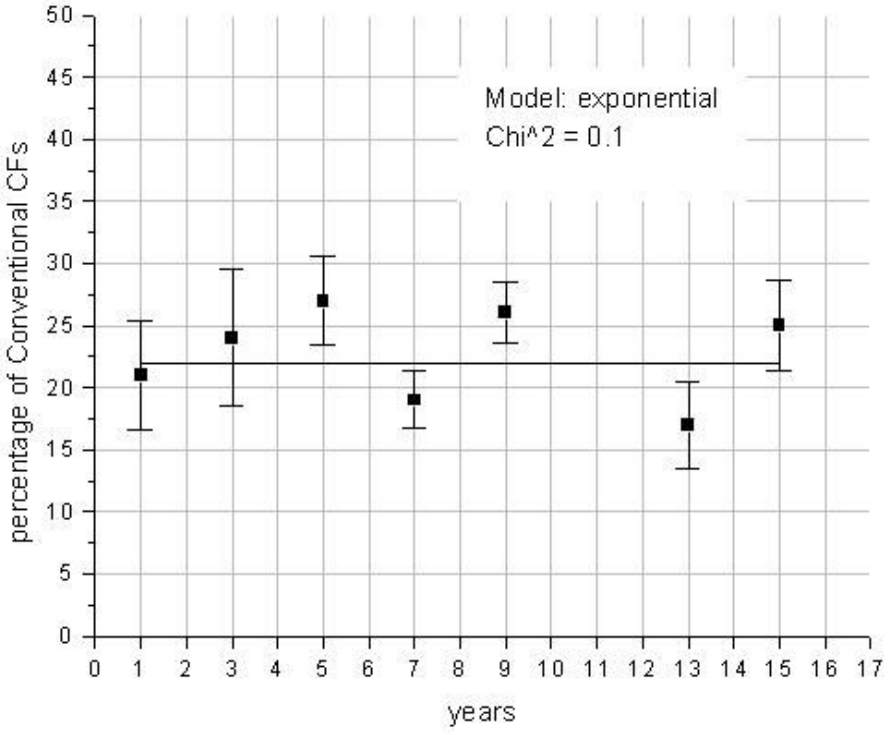


Figure 17 Trend for Conventional Contextual Frames

Figure 17 shows that in relation to time there is no change in the use of Conventional Contextual Frames as suggested by an exponential fit which in fact becomes a straight line around the 22% value parallel to the time axis, with a Chi-square of 0.1. This Chi-square value indicates a very good fit with a confidence level of nearly 100%. Once the researcher has chosen to use Contextual Frames, around 22% tend to be within the Conventional Category regardless of the researchers' experience: it is around the same percentage for first papers, middle papers and last papers. Here we

have a good fit with a rather uneventful trend. In order to see whether anything more can be deduced from the use of Conventional Contextual Frames, later on in the chapter the three different Conventional Subcategories will be examined separately.

9.3.3 Instantial Contextual Frames

We saw that in a similar way to Instantial Subjects, Instantial Contextual Frames involve wordings which researchers have had to come up with especially, in order to thrust the flow of discourse in ways which convey the meanings necessary for a text to be interpreted adequately by their peers. Instantial Contextual Frames are sometimes worded by means of grammatical metaphor, but of a different kind from the one present in Conventional Contextual Frames. We have seen above that Conventional Contextual Frame wordings sometimes include the referring-type of grammatical metaphor, whereas Instantial Contextual Frame wordings can comprise the expanding-type of grammatical metaphor used for reasoning and for carrying forward the momentum of the argument (Halliday 1998: 195 and 202). This explains in part why Instantial Contextual Frames can be either postmodified Circumstantials or whole clauses, either finite or non-finite, which are needed for reasoning from one process to the other and help the logical progression of the text.

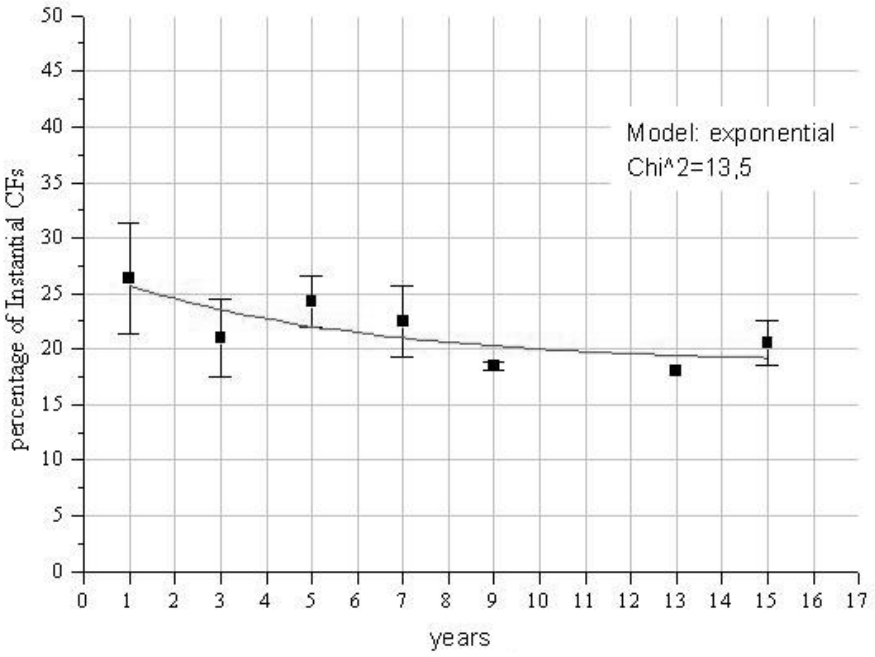


Figure 18 Trend for Instantial Contextual Frames

Figure 18 shows that there is a decrease in the use of Instantial Contextual Frames, from just above 25% to just below 20%. However, the fit around the points is not a reasonable one as indicated by the Chi-square value of 13.5. This high Chi-square value means that the confidence level is actually only 5%.

This decreace could be an interesting finding, as it shows an opposite trend to that shown for the selection of Subjects, and to that suggested in the pilot analysis. For Subjects the clearer trend is an increase of about 12% in Instantial Subjects over a span of sixteen years, and the pilot study indicates an increase in clause-like Instantial Frames.

Although the decrease indicated here has only a 5% confidence level, it is worth exploring further. The question would be why there might exist the possibility of Instantial elements in initial Theme position decreasing, whereas similar elements

placed in Subject position would increase. It will thus be necessary to examine each of the four different Instantial Subcategories in turn to see if confidence levels improve and enable us to better understand what could be happening at the linguistic level. This is what will be done later on in this chapter, in Section 9.4. But before going on to explore the subcategories, we shall now finish off looking at the broad Contextual Frame categories, and examine Expressive Contextual Frames.

9.3.4 Expressive Contextual Frames

Expressive Contextual Frames include all pre-Subject elements which contain an interpersonal strand of meaning. We saw in an earlier chapter that for the present corpus writers characteristically use projecting clauses to add this interpersonal strand.

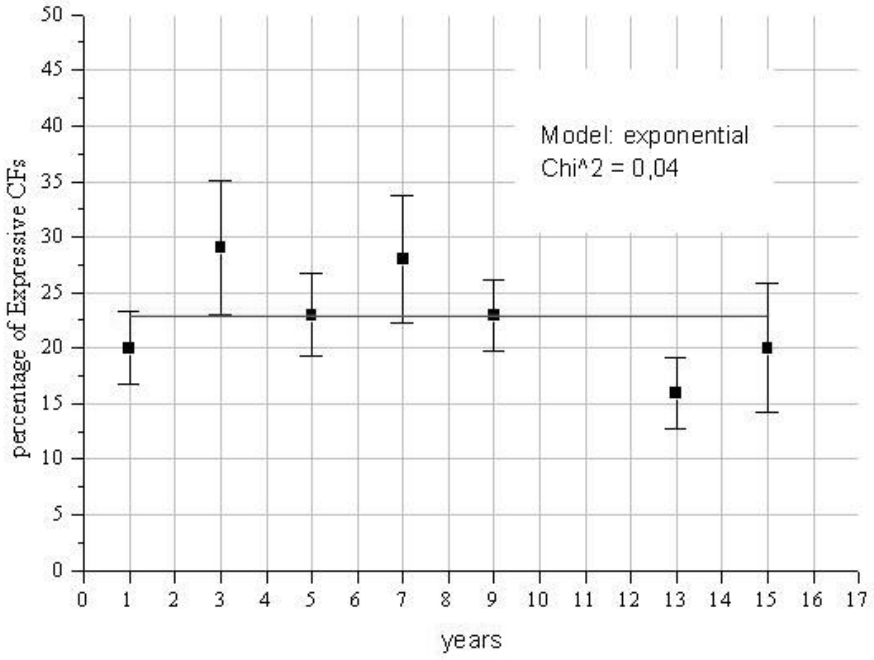


Figure 19 Trend for Expressive Contextual Frames

Figure 19 shows that in relation to time, there is no significant change in the use of Expressive Contextual Frames. Whether researchers have gained experience or not, their use of Expressive Contextual Frames seem to stay around 23% of total Contextual Frames. The fit is a very good one, with a Chi-square of 0.04 nearing a 100% confidence level. This result does not agree with the move towards the use of more Expressive Contextual Frames suggested by the pilot analysis and Research Question 8. This result will be explored further later on in this chapter in Section 9.4, where trends will be analysed for the two different subcategories included in the Expressive Category. Subcategory 10 will include Circumstantials or dependent clauses combined with an added expressive/interpersonal strand of meaning, whereas Subcategory 11 will group comparatively simpler Contextual Frames that are exclusively projecting clauses.

It will be interesting to see whether trends appear once these two subcategories are distinguished within the Expressive category.

9.3.5 Observations on trends for the four broad Contextual Frame Categories

In Figure 20 a preliminary picture is shown of trends emerging in the use of Contextual Frames as researchers gain experience. There would be no changes in the use of Conventional or Expressive Contextual Frames as time went by, as shown by the two dotted lines parallel to the time axis. Conventional Contextual Frames would stay around 22% and Expressive Contextual Frames around 23% of total Contextual Frames.

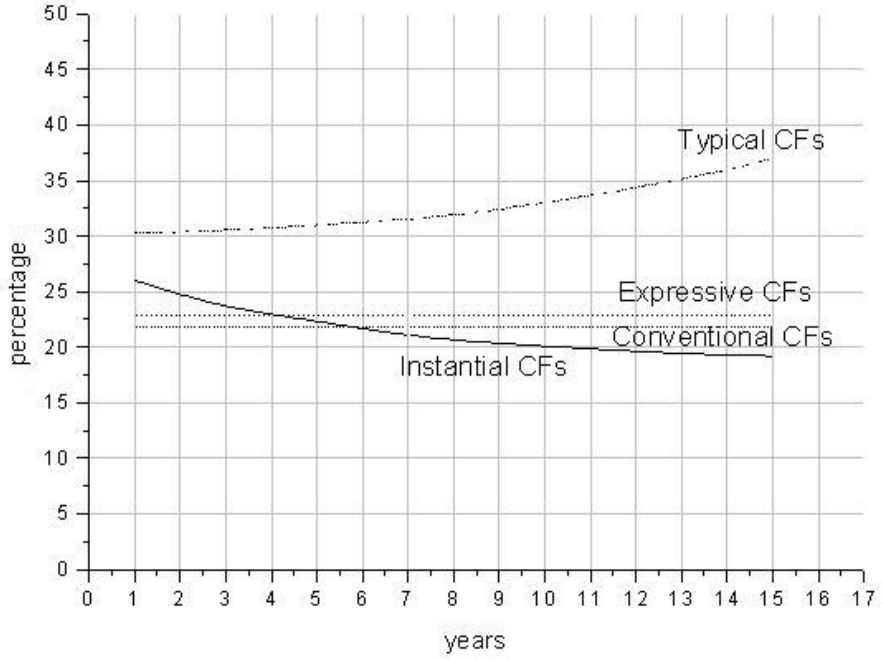


Figure 20 General trends for the four Contextual Frame categories

There would be a slight increase in Typical Contextual Frames as researchers gained experience of the order of 7% from first to last papers. This percentage would rise to about 37% in last papers.

Simultaneously, as Typical Contextual Frames gradually increased, there would be a decrease in Instantial -Type Contextual Frames of the same order, from just above 25% to just below 20% of total Contextual Frames. However, it should be borne in mind that the probability of this latter trend being a good model is low.

In sum, an approximate distribution of Contextual Frames according to the four categories initially distinguished would be for first papers to have a relatively even distribution of Contextual Frames from the four categories: around 22% for Conventional and 23% for Expressive Contextual Frames, around 25% for Instantial Contextual Frames, and about 30% of Typical Contextual Frames. As time went by category percentages would remain the same for Conventional and Expressive Contextual Frames, e.g. slightly less than a quarter each, but would become more differentiated regarding Instantial and Typical Contextual Frames. Last papers would tend to have just under 20% of Contextual Frames in the Instantial Category, whereas they would tend to have more than 35% of Contextual Frames in the Typical Category.

It is interesting to note that the taxonomy in its present state of four categories either shows no change, as for the Conventional and Expressive categories, or, if there are changes, they present different trends from those observed in the pilot study. Moreover, for Instantial elements in Contextual Frame position there might exist a possibility of an opposite trend to the one shown for Instantial elements in Subject position. We saw in a previous chapter that as time went by and as researchers gained experience, the percentage of Instantial Subjects nearly doubled. Here, albeit with a bad fit, similar heavily postmodified or clause-like elements would tend to decrease when in Contextual Frame position.

It is now time to explore in more detail the fact that results are generally different from those suggested by the pilot study. In particular, there seem to be no changes in some of the categories, unexpected trends in others, and a bad fit for the Instantial Category. The following section will gather further information on the way Contextual Frames evolve by examining trends for the eleven subcategories.

9.4 Results of the Contextual Frame analysis considered as one sample: exploring exponential relations with time for the eleven subcategories

9.4.1 Method of Analysis

The previous section showed trends for the four broad categories of Contextual Frames. The purpose is now to refine the analysis, one of the reasons being that for two categories no changes were observed. By distinguishing subcategories, trends might show up that hitherto were hidden. Another reason for refining the analysis is the rather interesting finding that Instantial elements in Contextual Frame position would behave in an opposite way to similar elements in Subject position, although this finding is a very tentative one because of the high Chi-square value and consequent low confidence level. Here again, by examining trends for subcategories further insights might be gained not only on the behaviour of Instantial elements in Contextual Frame position, but also on the increase of Instantial elements in Subject position.

Yet a further reason for distinguishing subcategories is the fact that Contextual Frames are realised by a much wider range of linguistic elements than are Subjects. To make this last point clearer, writers are faced with a number of options when choosing Subjects, but these options are necessarily much more restricted than for Contextual Frame. Subjects are not only obligatory, but they also have a prototypical - in the sense of 'most typical' – realisation which is the nominal group.

Regarding Contextual Frames we know first, that writers can choose whether to use a Contextual Frame. Second, if writers have opted for a Contextual Frame, there is no prototypical realisation. Contextual Frames can for instance be conjunctive or modal Adjuncts, conjunctions, prepositional groups, or clauses of different type such as dependent clauses, non-finite clauses and projecting clauses.

On the basis of this wealth of different possibilities for the realisation of Contextual Frames, and of the need to understand in greater depth the trends shown for the four categories, eleven different subcategories have been characterised, two within the Typical Category, three within the Conventional Category, four within the Instantial Category, and two within the Expressive Category. There is one figure corresponding to each sub-category.

Trends for each of these subcategories will now be discussed in turn. Whereas in the previous section all the figures were drawn on a scale of 50% (vertical axis), in the present section, because subcategories necessarily represent lower percentages, the scale is halved to 24%. It has been halved to 24% rather than 25% because of the way the programme used for the graphics showed grids: an even maximum value enabled me to have major grids every two per cent. An odd maximum value obliged me to either have major grids every unit – giving a rather cumbersome picture – or every 2 and a half units, which was slightly more awkward for discussing general trends than the present solution of every two units. There is one exception to this: the first figure, Figure 21, showing trends for Subcategory 1 Conjunctions and Conjunctive Adjuncts, still uses a scale of 50% for the vertical axis because of all the subcategories it is the one with the highest percentage, and the only one to have maximum values above 24%.

9.4.2 The two Typical Subcategories

Let us now see what happens when one distinguishes two Typical Subcategories. Trends for Subcategory 1, Conjunctions and Conjunctive Adjuncts, are presented in Figure 21 and trends for Subcategory 2, Modal Adjuncts, are presented in Figure 22. It should be remembered that the vertical axis of Figure 21 represents percentages going up to 50%, whereas the vertical axis of Figure 22 goes up to 24%, as do all the other figures in this chapter. Figure 21 had to be drawn at double the scale of other figures, because it shows the most numerous subcategory.

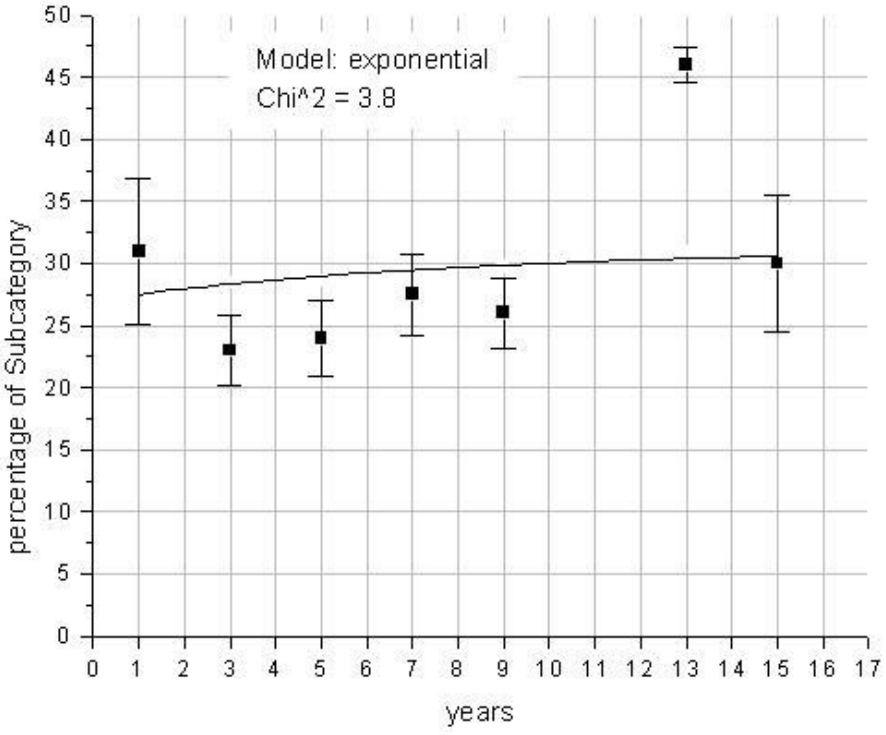


Figure 21 Trend for Subcategory 1, Conjunctions and Conjunctive Adjuncts

The first observation that can be made is that the most frequent items of the Typical Category are conjunctions and conjunctive Adjuncts. As pointed out in the introduction,

this subcategory is actually the most numerous of all 11 subcategories. Figure 21 shows that practically all the papers show a band of use of conjunctive Adjuncts ranging from 20% to 35%. When fitting an exponential curve, there is a slight increasing trend showing up, from around 27 to around 30%, with a confidence level of around 70%.

Figure 22 Trend for Subcategory 2, Modal Adjuncts

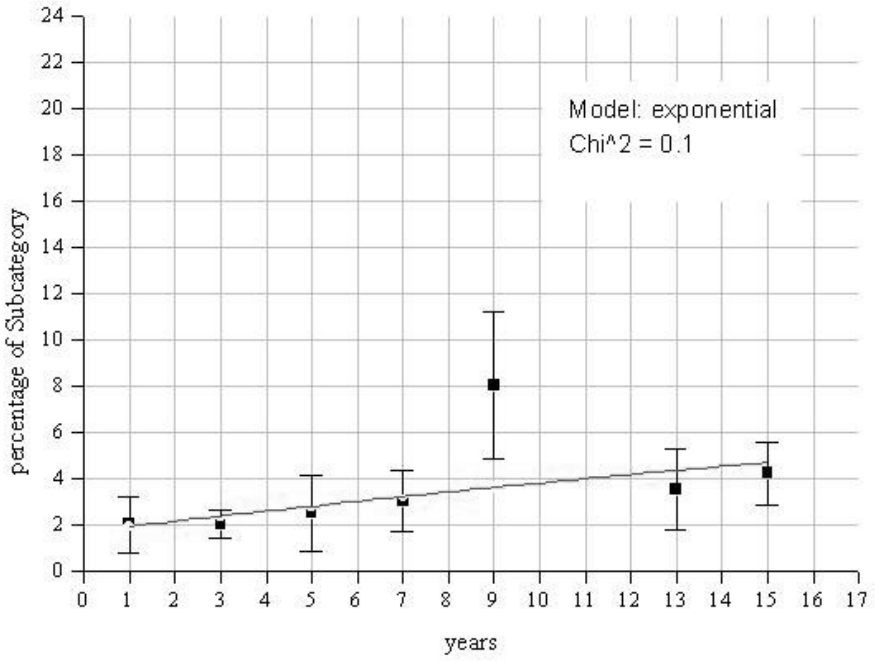


Figure 22 shows that the use of modal Adjuncts is much lower in the corpus, with most papers within the 1 to 6% band. However, in relative terms there is an increasing trend than for conjunctions and conjunctive Adjuncts, with an excellent fit as shown by the Chi-square of 0.1 and a confidence level nearing 100%. First papers would tend to have around 2% of their Contextual Frames within Subcategory 2 of modal Adjuncts, and last papers would tend to more than double this amount, i.e. around 5% of such Contextual Frames.

Figure 21 and Figure 22 help us see that in fact, within the Typical category the growth of modal Adjuncts as researchers gain experience is greater in relative terms than the one affecting conjunctive Adjuncts. In other words, although the great majority of the Typical Category is made up of Subcategory 1 Conjunctive Adjuncts, only about half the increase in that category in relation to time is due to this first subcategory. The other half affects the lower values of Subcategory 2 Modal Adjuncts, which nearly double. Modal Adjuncts are interesting in the sense that they are 'Typical' Contextual Frames, but at the same time, they also have a slight 'Expressive' flavour. However, it is suggested here that this 'Expressive' flavour is not as strong as their 'Typical' characteristic, which is why they are classified as belonging to the Typical Category.

9.4.3 The three Conventional Subcategories

9.4.3.1 Subcategory 3, Circumstantials of Location (Theory, Discourse and Time) without postmodification

We saw in the previous chapter that when looking at the Conventional Category as a whole, there seems to be no clear indication of changes in the use of Circumstantials belonging to this category. However, when separating Circumstantials of Location, as is done in Figure 23, a clear trend does appear. Moreover, a Chi-square value of 1.2 indicates a confidence level of more than 95%. In first papers Circumstantials of Location would tend to represent around 10% of Contextual Frames. As researchers gained experience, they would tend to increase their use of such Cirmcumstantials to around 16% in last papers. We saw in the corresponding chapter that Circumstantials of Location were given a whole subcategory to themselves, because they represented an important percentage of Contextual Frames within the present corpus.

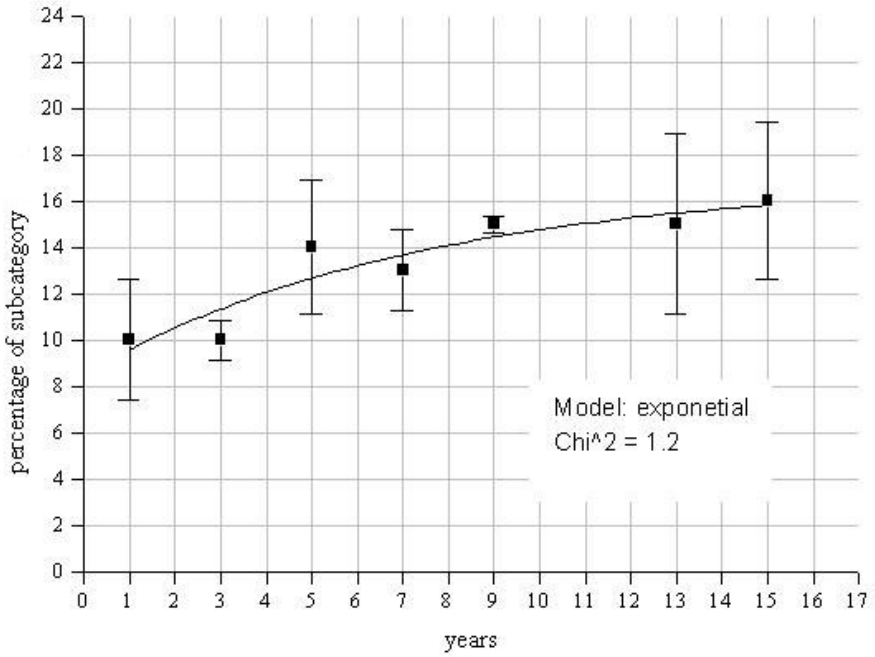


Figure 23 Trend for Subcategory 3, Circumstantials of Location

9.4.3.2 Subcategory 4, Circumstantials of Cause and Condition without Postmodification

When we examine the next subcategory of the Conventional Category, non-postmodified Circumstantials of Cause and Condition, the trend indicated by Figure 24 does not change in relation to time, with roughly 2% of Contextual Frames within this subcategory. The fit is a very good one, indicating that there is practically a 100% chance of the model indicated by the curve being a good description of the behaviour of such Circumstantials, although it should be kept in mind that overall they have very low values.

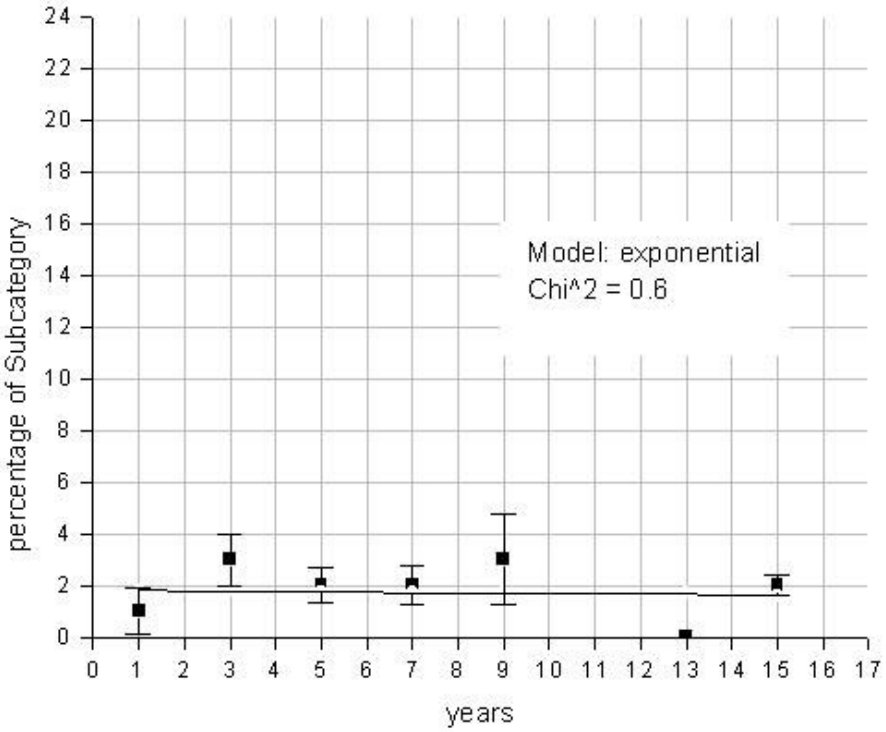


Figure 24 Trend for Subcategory 4, Circumstantials of Cause and Condition without postmodification

9.4.3.3 Subcategory 5, Other Circumstantials (mainly Matter and Angle) without postmodification

Finally, when we examine other types of non-postmodified Circumstantials from the Conventional Category, mainly of Matter and Angle and some isolated cases of Role and Manner/Quality, the trend shown in Figure 25 is not as clear as in the previous two figures. The fit of the curve is not a good one as shown by the Chi-square value of 54. There would be a vague indication towards a decrease in the use of such Circumstantials from around 10% to around 6%, but the fit is not a good one, and the confidence level is practically nil.

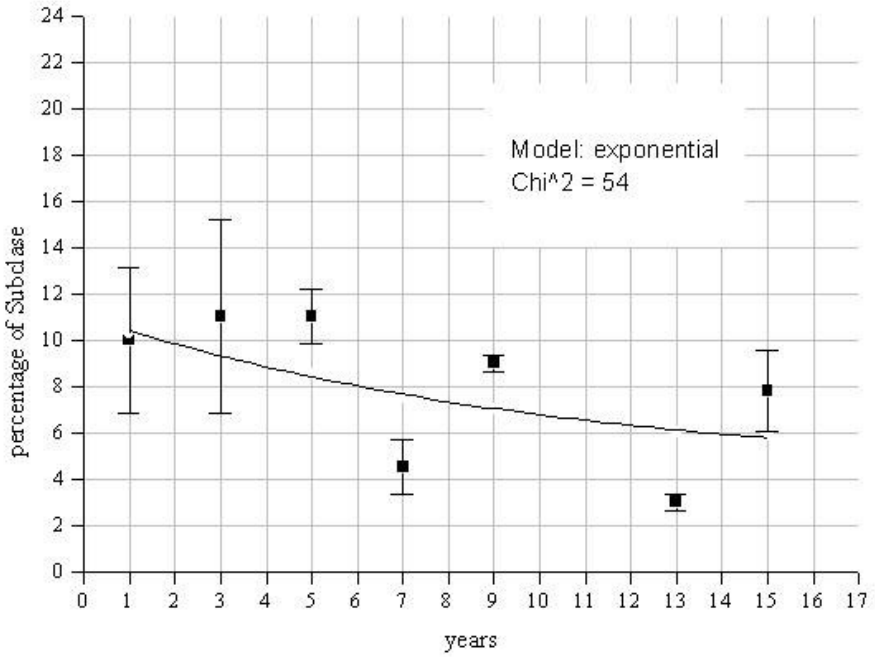


Figure 25 Trend for Subcategory 5, Other Circumstantials without postmodification

9.4.3.4 General observations for the three Conventional subcategories.

Reliable conclusions can be drawn for Subcategories 3 and 4, but not for Subcategory 5. It now becomes possible to understand much better some of the hidden trends behind the initial indication of no changes for the whole of the Conventional Category. Circumstantials of Location (Subcategory 3) represent an important part of the Conventional Category and clearly increase. As shown in Figure 23, in first papers they represent slightly less of half the Conventional Category, and in last papers they clearly represent much more than half that category. There would be signs of a decrease in the other most numerous category, i.e. Subcategory 5, other Circumstantials without postmodification, but because the fit of the curve is bad, no firm conclusion can be drawn.

However, the signs pointing towards an eventual decrease of such Circumstantials enables us to understand why initially, when the Conventional Category was looked at undivided, there were no indications of change: the increase in Subcategory 3 was probably blurred by the erratic behaviour of Subcategory 5, giving a general picture of no change. However, this latter picture of no change is confirmed for Subcategory 4, non-postmodified Circumstantials of Cause and Condition: their use would stay roughly around 2% as time went by.

9.4.4 The four Instantial Subcategories

When looked at undivided, the Instantial Category suggested, albeit tentatively and with not a good fit, that as researchers gained experience, there could be a decrease in the use of such elements in Contextual Frame position. It now becomes necessary to try and gain a better insight into trends regarding Instantial Contextual Frame, in part because the fit was not a good one, and in part because of the greater diversity of Instantial linguistic elements that can be chosen for the Contextual Frame slot. The Instantial Category has been divided into four subcategories: two different types of postmodified Circumstantials, and two different types of clausal Contextual Frames positioned before main Subjects.

We had three subcategories for Circumstantials belonging to the Conventional Category (i.e. Circumstantials without postmodification), and now only two for Circumstantials belonging to the Instantial Category (postmodified Circumstantials). Only two subcategories are needed here because postmodified Circumstantials are less frequent, as we shall see in the figures below, and in particular there are virtually no postmodified Circumstantials of Location.

9.4.4.1 Subcategory 6, Postmodified Circumstantials of Cause and Condition, and Subcategory 7, Other Postmodified Circumstantials

Both Figure 26 and Figure 27 suggest that researchers would not tend to change their use of postmodified Circumstantials as they gained experience. Figure 26 shows Subcategory 6, Postmodified Circumstantials of Cause and Condition, which involves only about 2% of total CFs. The Chi-square value of 2.9 indicates a confidence level of nearly 90%.

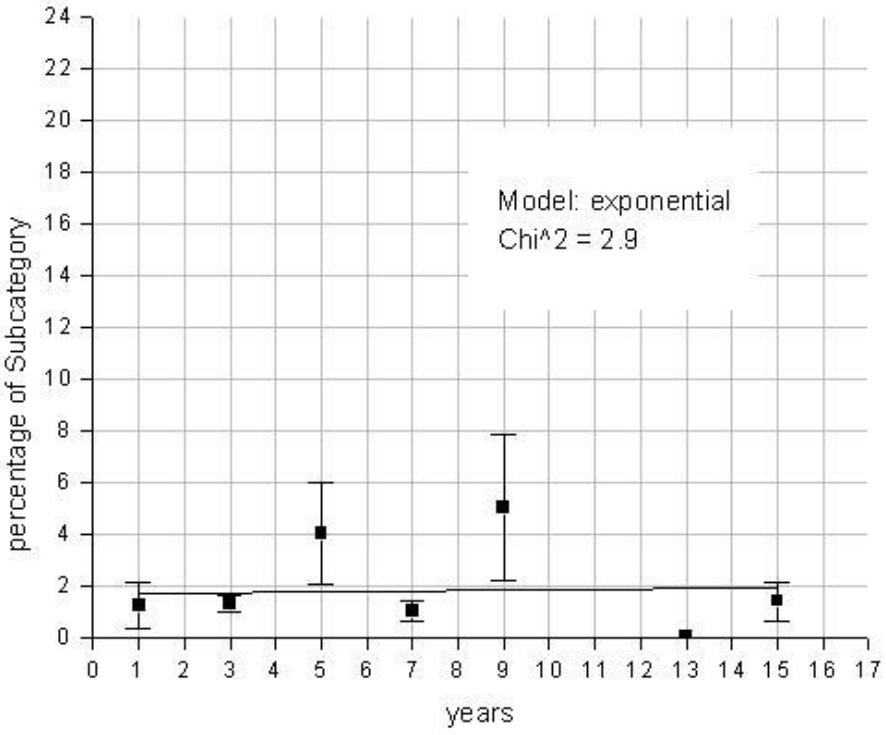


Figure 26 Trend for Postmodified Circumstantials of Cause and Condition

Figure 27 below shows Subcategory 7, Other Postmodified Circumstantials, which involves about 4% of total CFs. The fitted curve presents a confidence level nearing 100%, as indicated by the Chi-square value of 0.6.

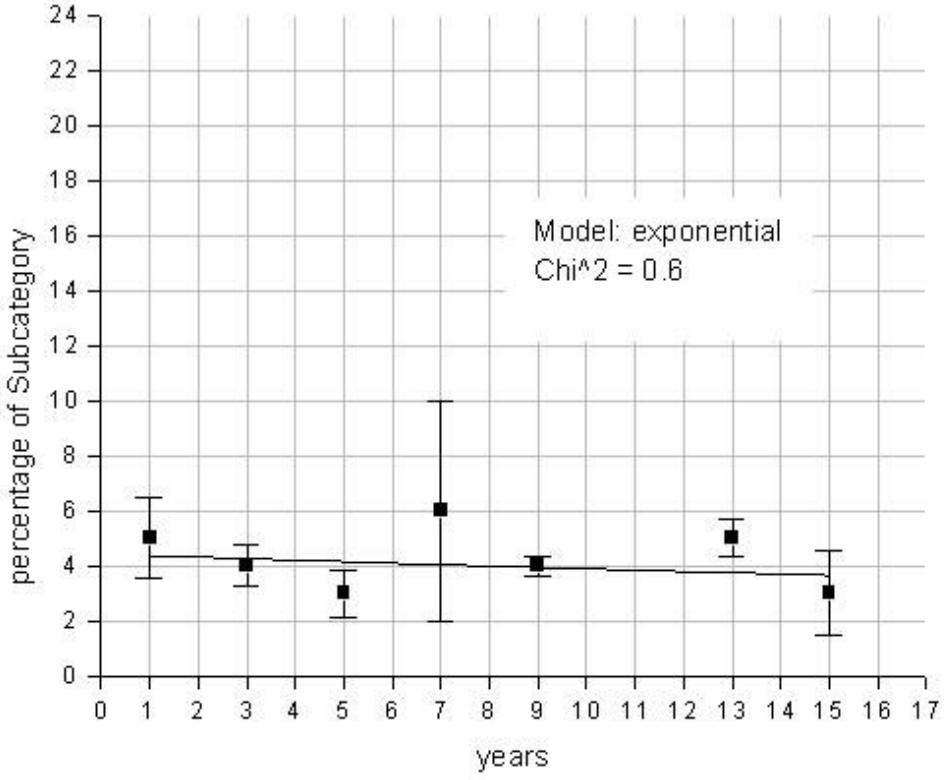


Figure 27 Trend for Other Postmodified Circumstantials

Figure 26 and Figure 27 further indicate that the decrease in the Instantial Category as a whole is not due to Circumstantial elements. There would be a tendency for very little change in the use of Circumstantial elements in general – whether postmodified or not – as time went by with the exception of an increase in Location CFs from the Conventional Category.

9.4.4.2 Subcategory 8 Finite Clauses mainly of Cause/Reason & Result and Condition

If we now turn to Subcategory 8, Dependent Finite clauses in Contextual Frame position, the fitted curve in Figure 28 shows a very slight decrease from rough values of

under 8% to just above 6%. However, the Chi-square of 15,4 indicates a bad fit, with an extremely low confidence level of around 2%.

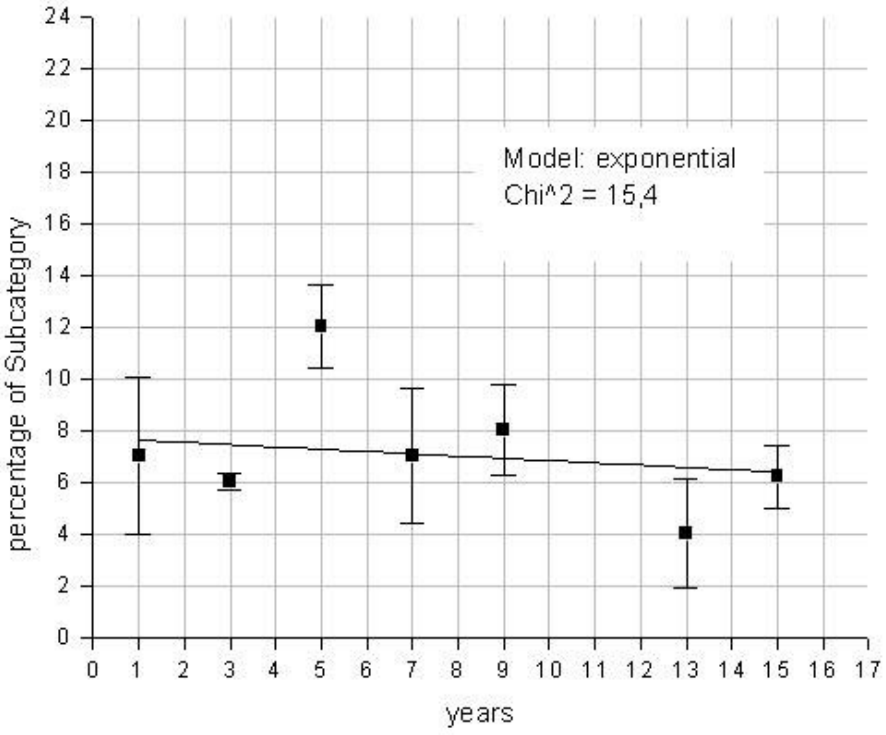


Figure 28 Trend for Finite Clauses

9.4.4.3 Subcategory 9: Non-Finite clauses

Finally, Figure 29 concerning non-finite clauses in Contextual Frame position does show a much better trend towards a decrease in the use of such elements from around 12% to around 7%. The Chi-square of 1,5 indicates that the confidence level is above 95%.

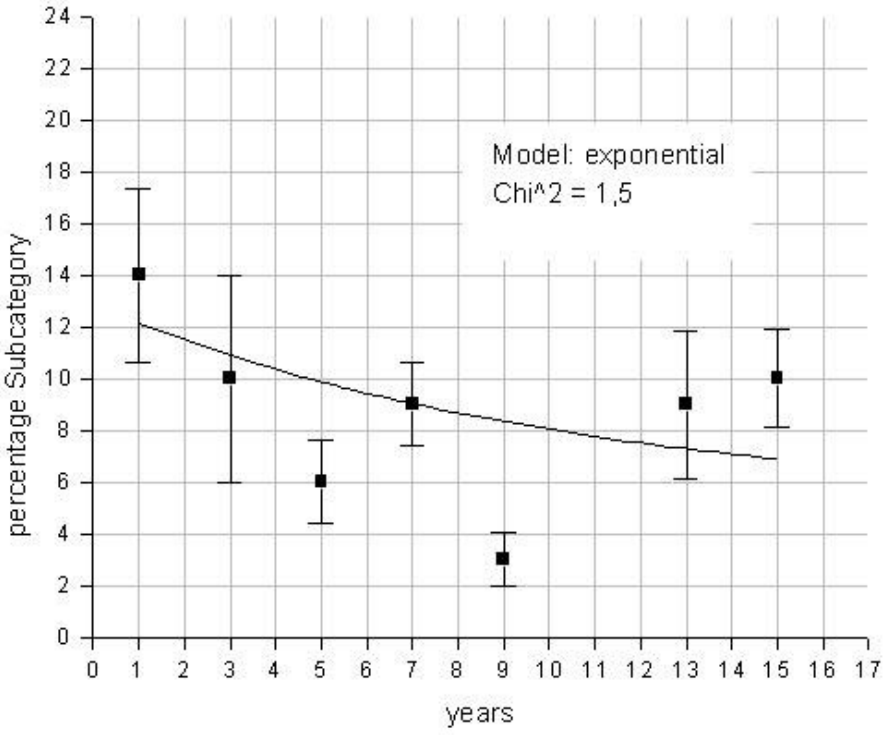


Figure 29 Trend for Non-finite Clauses in Contextual Frame Position

9.4.4.4 General observations for the four Instantial subcategories

By looking at the Instantial Category in more detail we can see that the decrease shown for the category as a whole is mainly due to a decrease in Non-finite Clauses, Subcategory 9, which is the most numerous Instantial Subcategory.

Subcategories 6 and 7 with postmodified Circumstantials tend not to show changes in relation to time. They are also the subcategories with the lowest percentages: combined together, researchers would be inclined to use about 6% of such elements regardless of time.

Little can be said about the remaining Subcategory 8, Finite Clauses in Contextual Frame position, because data could not be fitted satisfactorily from the statistical point of view.

9.4.5 The two Expressive Subcategories

We saw above that for the Expressive Category as a whole the model indicated no change as researchers gained experience in the use of such Contextual Frames. To explore in more detail this finding, which is rather different from what was expected after having done the pilot analysis and posed the corresponding research question, the two Expressive subcategories will be examined separately. Subcategory 10 is concerned with Circumstantials or clauses with an added interpersonal strand of meaning mostly of the projecting kind, and Subcategory 11 includes projecting clauses on their own.

Figure 30 and Figure 31 show trends for the subcategories. Interestingly, the two figures show differences. Figure 30 below shows a decrease in more complex Contextual Frames with an added interpersonal strand of meaning from around 15% to around 10%. The fit is very good, with a confidence level of practically 100%.

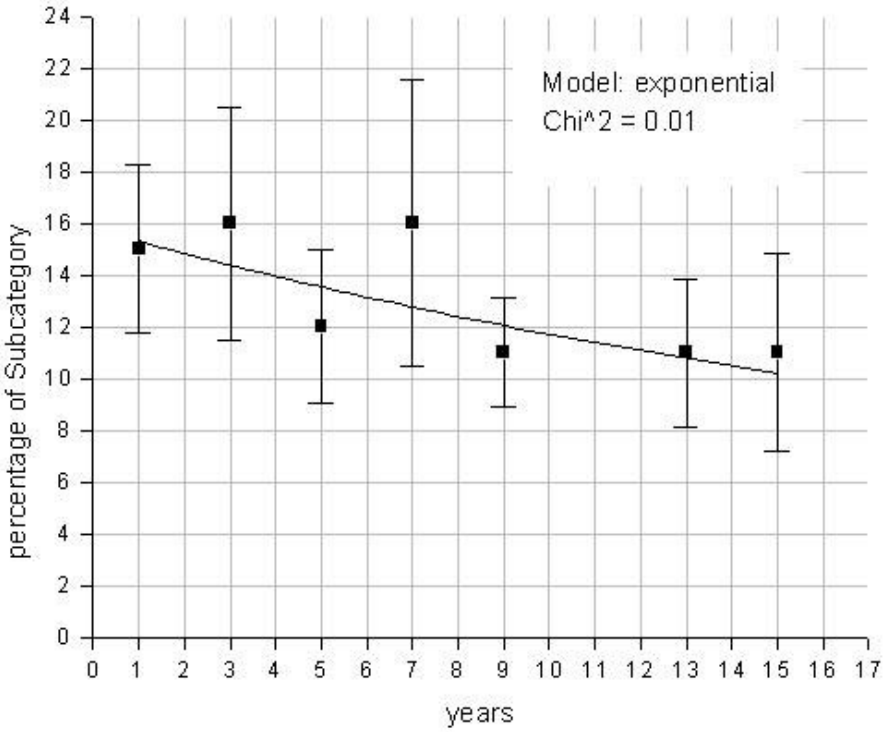


Figure 30 Trend for Circumstantials and Clauses with embedded evaluation

In contrast, Figure 31 for projecting clauses on their own shows an indeterminate trend, with a curve tending towards a slight increase. However, the fit is so bad that the confidence level is practically zero.

These two figures considered together suggest that the decrease in Contextual Frames with embedded evaluation (Subcategory 10) is blurred by the very bad fit concerning projecting clauses on their own (Subcategory 11), which could explain why, when taken together as the Expressive Category, a fitted curve shows no change.

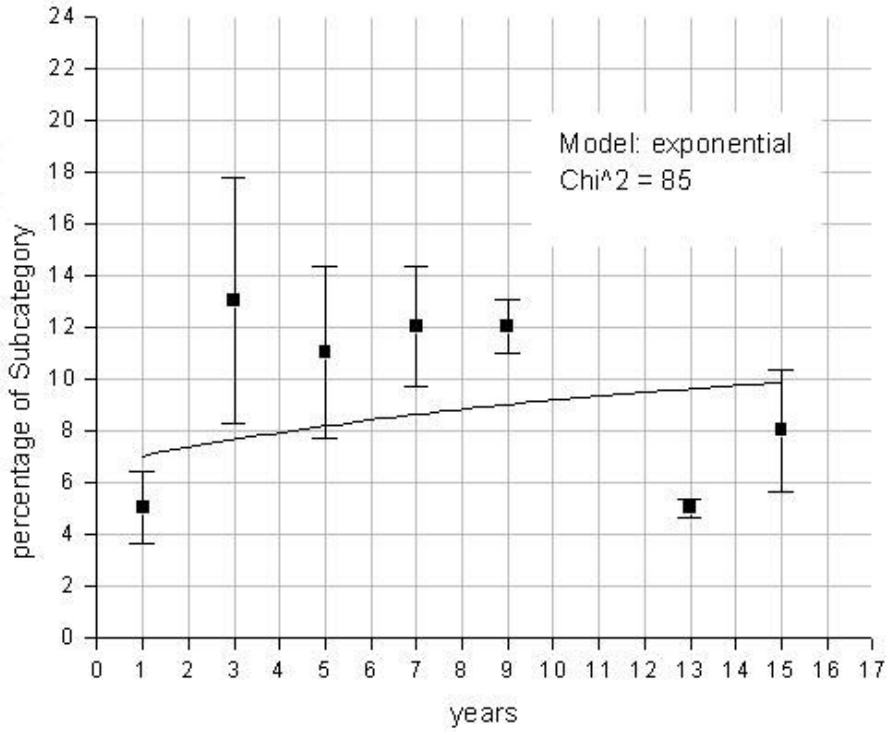


Figure 31 Trend for Projecting Clauses

9.4.6 General results for the eleven subcategories

We have seen that the Typical Category showed an increase of around 6%. When subdividing the category in two subcategories, one for conjunctions and conjunctive Adjuncts, and another for modal Adjuncts, this increase is somewhat evenly shared in absolute terms by both subcategories. However, as conjunctive Adjuncts represent the great majority of the category, their increase in relative terms is much smaller than for modal Adjuncts which more than double in value and are better fitted by the curve.

The Conventional Category looked at as a whole showed no trend towards change. Once the Conventional Category was subdivided into three subcategories, this rather static picture was confirmed for only one subcategory, Subcategory 4, Circumstantials

of Cause and Condition, which moreover represents the smallest part of the Conventional Category. The clearest and more relevant trend within this category is shown by the largest subcategory, Subcategory 3, Circumstantials of Location, with an increase over time of around 6%. The third subcategory showed an erratic trend with a confidence level of practically zero that initially blurred the increase in Circumstantials of Location when the category was examined as a whole.

The Instantial Category as a whole indicated a decrease of the order of 6%. However, the decrease was not statistically significant due to a very low confidence level. It was then subdivided into four categories. The first two concerned with postmodified Circumstantials showed no change over the years. The last two subcategories, concerned with clausal elements in Contextual Frame position, did show a decline in their use. The drop was statistically significant and of the order of 5% for Subcategory 9, non-finite clauses, which are the most numerous Instantial CFs.

The Expressive Category looked at undivided, in a similar way to the Conventional Category, showed no discernible trend towards change. However, here again, when subdividing it into two categories, different trends began to appear. The most significant and interesting trend was a decline of the order of 5% in the largest subcategory, Subcategory 10, Circumstantial and clausal type elements with an added interpersonal strand. When the class was looked at as a whole, this decline was blurred by very erratic results for Subcategory 11, Projecting clauses.

In sum, the most statistically significant trends that now show up are the following: both conjunctive and modal Adjuncts (Subcategories 1 and 2) show increases of the order of 3% each, with a much greater relative increase for modal Adjuncts. Circumstantials of Location (Subcategory 3) rise from around 10% in first papers to around 16% in last papers. So much for increases. The confidence levels are the following: of the order of 70% for Subcategory 1, nearly 100% for Subcategory 2, and 98% for Subcategory 3.

Regarding statistically significant decreases, the two subcategories affected are of the clausal type. Decreases affect non-finite clauses (Subcategory 9) that go from around 12% in first papers to around 7% in last papers, and clauses with embedded interpersonality (Subcategory 10) that go from around 15 to around 10%. The confidence levels are of the order of 95% for Subcategory 9 and nearly 100% for Subcategory 10.

There are three subcategories that show statistically significant unchanging trends. These are Subcategory 4 (Cause and Condition Circumstantials without postmodification), Subcategory 6 (Postmodified Cause and Condition Circumstantials), and Subcategory 7 (Other postmodified Circumstantials), where total percentages stay around 8%, i.e. 2% each for Subcategories 4 and 6, and 4% for Subcategory 7. The confidence levels are of the following orders: nearly 100% for Subcategory 4, 80% for Subcategory 6 and nearly 100% for Subcategory 7.

No conclusions can be drawn as to trends in the use of the remaining three categories, because of bad fits and confidence levels nearing zero. These erratic behaviours concern other Circumstantials without postmodification (Subcategory 5), dependent finite clauses (Subcategory 8) and projecting clauses (Subcategory 11).

9.5 Conclusion

On the basis of trends for the eleven subcategories examined in the present chapter, more delicate[28] conclusions have been drawn regarding tendencies in the use of Contextual Frames as researchers gain experience. We started with four categories, and ended up with a more delicate taxonomy of eleven subcategories. The original four categories each embraced a very general area of meaning. Typical Contextual Frames contained more textual meanings. Conventional Contextual Frames covered more experiential meanings that were traditional ones within the field of research concerned. Instantial Contextual Frames also covered experiential meanings, but of a more complex nature, often involving the more reasoning type of grammatical metaphor (Halliday 1998:201) and also entailing multiple strands of meaning. Finally, Expressive Contextual Frames had to have an interpersonal strand of meaning to be classified as such.

On the basis of the results obtained when analysing the corpus, it was then felt that these general areas of meaning should be broken down into smaller subcategories, to gradually make more delicate distinctions in meanings via different grammatical

[28] The word *delicate* is used here in the sense given to it by Margaret Berry: 'We can arrange systems on a scale according to the fineness of the distinctions in meaning which they represent. This scale is called the scale of *delicacy.*' (Berry 1975, reprinted 1989:177).

realisations. Results have become gradually more delicate as the present chapter progressed.

The results above suggest that what could be seen as 'simpler' pre-Subject elements with a strong Logical[29] flavour, of a textual[30] and locational[31] nature, would tend to increase, whereas more 'complex' clause–type elements expressing multiple meanings in that same position would tend to diminish as researchers gained experience. Furthermore it could be argued that textual-type meanings, or the more straightforward location meanings within the Experiential, have a much stronger Logical flavour than meanings involving multiple strands, not only of an Experiental nature, but also of an Interpersonal nature.

At this point it might be useful to remember that Theme, at a broader metafunctional level than the one discussed in the previous paragraph (see footnote 27) has to do with the organisation of the clause as message, and hence with Textual meanings. It is considered in the present work as being made up of two different elements: Subject, which is obligatory, and Contextual Frame, which is optional. Theme is seen as having two different functions: one is the obligatory semantic function of identifying the 'topic' of the clause, which would be mainly done via Subject, and the

[29] In Chapter 4, Section 4.5.3, I discussed the difficulties inherent to using metafunctional labels, especially regarding the "Logical" and "Textual" ones. In particular, I mentioned how Berry (1996) had alluded to the problem inherent to Halliday's use of "Textual" in two different ways. In a broad sense Halliday defines it as 'creating relevance to context' (IFG1994: 36) and as enabling other types of meaning through culminative positioning. In a narrow sense he classifies particular types of Theme as 'Textual Theme', (IFG 1985: 54; IFG 1994: 53-4). Berry points out that items such as *however* and *in addition*, which are examples of what Halliday calls Textual Themes, do not seem to be enabling the prioritisation of interpersonal or experiential meanings, but rather seem to have a type of meaning of their own, which in turn would need to be enabled by being placed in certain positions. Berry then suggests that this type of meaning appears to be logical meanings.

[30] I do not capitalise textual in this case, because it is clearly used in the narrow sense.

other is to provide 'different frameworks or contexts for the development of topic as the discourse proceeds' (Davies 1988:177), which would be the main role of Contextual Frame.

We know that Contextual Frame is an extra choice writers make when writing up. However, it is a choice only up to a certain point. This can be seen in the present corpus, where there is a tendency for writers to opt for filling at least one quarter and no more than three quarters of the Contextual Frame slots. Moreover, we saw that this range of use tended to narrow down as writers gained experience to percentages ranging from 43 to 61%. This use of Contextual Frames, which is a choice only up to a certain point, can be explained in part by the strong Logical component of Contextual Frames. This strong Logical component implies that some Contextual Frames are actually necessary for the flow of the text and/or for its organisation. So, I would like to suggest that there would be more 'simple' and 'characteristically Logical' Contextual Frames, such as conjunctive and modal Adjuncts, and Location Circumstantials, whose position as a pre-verbal element would be substantially – or completely – obligatory, and more 'crafted' and less 'obligatory' Contextual Frames, notably clause-type Contextual Frames, where the option for them to go after the Subject and predicate of the main clause would be greater because they have less to do with the actual logical flow of the text.

A possible explanation could be that as researchers gained experience, they would tend to reduce the use of complex and multiple meanings in Contextual Frame position in order not to overload the reader, and would concentrate on using more Contextual

[31] Circumstantials of Location are experiential, but perhaps what would also make them have a strong logical flavour would be the location-type meanings they express?

Frames with a stronger logical flavour whose function would have more to do with the flow of the text. Not overloading the reader at the beginning of sentences could be especially important if we simultaneously take into consideration results for Subject. These issues which will be addressed in the last chapter where the research questions, both for Subject and for Contextual Frame, will be reexamined in the light of the results obtained from the extended analysis.

Chapter 10 Conclusions and suggestions for future research

10.1 Introduction

The present longitudinal study has analysed choice of Subject and Contextual Frame over time to find ways of understanding differences in thematic choices as scientists, already familiar with research article conventions, develop as writers. The main concern has been to determine how Subject and Contextual Frame choices evolve as writers gain experience in publishing their work. In order to develop indexes of writer development it was necessary to revise the criteria for some of the original categories of the Davies (1988,1997) and Gosden (1996) taxonomies.

One of the outcomes of setting up new categories was distinguishing Conventional and Instantial categories when coding both Subjects and Contextual Frames. Halliday's discussion of a cline from a Type 1 metaphor for referring and taxonomising to a Type 2 metaphor for expanding and reasoning was crucial for establishing these new categories. Halliday observed that with time, the instantial form of Type 2 expanding/reasoning metaphor sometimes ended up as a Type 1 referring/taxonomising metaphor when it became part of the language system of a given genre. This was in line with what I could distinguish in novice researcher

writing, where researchers' use of referring and taxonomising elements appeared to be successful. The difference, as they gained experience, was in the use of expanding and reasoning type elements. Thus Halliday's observations forced a more detailed look at the grammatical structure of the noun group, which prompted my thinking along the Conventional/Instantial lines that were to lead to new categories.

As a result, Conventional wordings, both in Subject and in Contextual Frame position, are identified as being expressions which are readily available to novice writers of articles, because they are commonly used terms in the fields of research concerned. In contrast Instantial wordings are identified as being expressions which have been especially contrived by the writer to fit a given stretch of discourse. As writers develop and make their own the matter with which they are working, they become increasingly capable of crafting these more complex wordings which involve multiple strands of meaning. In the case of this latter class, particular reference is made to post-modification and clause-type elements which allow meanings to be combined in specific ways.

As the research progressed, questions evolved which have motivated and driven the new taxonomy. In the following I summarise these research issues and discuss the main findings.

10.2 Subject Trends

To obtain a clearer understanding of the evolution of Subjects, the research has shown the potential of distinguishing four main categories: Instantial,

Conventional, Participant and Discourse Subjects. When writers gain experience, the relative use of these four types of Subjects change as discussed below.

10.2.1 Evolution of Instantial Subjects

A first question about the evolution of Subjects concerns the tendency to use Instantial Subjects as scientists gain experience as writers. More explicitly, it is important to know whether there is a move towards the expression of Subject choices which have been especially fashioned to create new experiential wordings, and which sometimes may have an added interpersonal strand.

The analysis of the corpus confirms that a trend in such a sense does in fact exist. The correlation analysis shows that the strongest linear relation existing between paired variables is the one between time and Instantial Subjects: over time researchers become increasingly capable of writing up the more subtle and complex Instantial Subjects needed for arguing their case. However, there comes a point where the growth of these Subjects starts to level off, because of their very nature. Instantial Subjects tend to be long and often involve extensive pre and post-modification.

An exponential fit quantifies this previous analysis. Instantial Subjects in first publications at Year 1 represent around 20% of total Subjects, and increase to a value just below 40% by Year 15 – the maximum time span for last publications. Most of the growth occurs up to Year 5, after which the rate of growth starts to slow down.

These results suggest that physics papers written by experienced researchers have comparatively more Instantial Subjects than papers written by novice researchers. First papers start off with around one fifth of their Subjects in the Instantial Category. Papers published five years later have around one third of their Subjects in the Instantial Category. From then on, increases in Instantial Subjects are very slight and quickly reach a plateau of just below 40%.

10.2.2 Evolution of Conventional Subjects

For Conventional Subjects the question centred on whether they would decrease. The rationale for such a tendency would be that experienced writers became increasingly capable of designing the kind of experiential wordings they needed by using Instantial Subjects, rather than continue using the more conventional and pre-formulated expressions typical of their field of research.

The corpus analysis has confirmed a decreasing trend for Conventional Subjects. Physics papers written by experienced researchers will have fewer Conventional Subjects than papers written by novice researchers. However, this decrease is less drastic, both in relative and in absolute terms, than the increase shown by Instantial Subjects. The difference between first and last papers is of the order of 10%.

An exponential fit quantifies the following proposition concerning the evolution of Conventional Subjects. First papers will have about 55% of their Subjects in the Conventional Category, whereas last papers will have less than half such Subjects. Here again there comes a point in time around Year 5 when

the rate of reduction becomes much smaller and a plateau is reached from Year 10 onwards, with experienced writers still using around 45% of Conventional Subjects in their papers.

10.2.3 Evolution of Participant Subjects

For Participant Subjects, the question centred on whether writers would choose to be more visible as they gained experience. The corpus analysis did not corroborate such an assumption. Results suggest that uses of Participant Subjects in the research article in physics are much more a matter of individual choice than Instantial and Conventional Subjects. This is supported by the fact that the decrease shown by the best explanatory curve available for the data is only significant at the 50% level, indicating the lack of a clear trend which would be common for writers in general.

Results for standard deviations also point towards the fact that Participant Subjects are greatly influenced by individual choices: these deviations are much higher for Participant Subjects than for Instantial and Conventional ones.

These results for Participant Subjects lead to the assumption that the presence of more overt interpersonal strands in Subject position does not seem to depend upon the experience of the writer. The evolution of overt interpersonal strands for Theme in general will be discussed further once assumptions are also posed for the presence of these meanings in Contextual Frame position.

10.2.4 Evolution of Discourse Subjects

The question regarding the evolution of Discourse Subjects was an entirely open one, i.e. whether there were any discernible changes in the use of such Subjects as researchers gain experience. The analysis has shown that there is no clear trend in the use researchers make of Subjects in the Discourse Category as time goes by. A further look at the data when trying to fit a curve has confirmed the lack of a distinguishable trend in the evolution of Discourse Subjects, as manifested by an extremely low confidence level. Moreover, Subject percentages for the Discourse Category are persistently very small, of 1% or less in nearly half of the papers. For all these reasons Discourse Subjects in the present corpus can be taken as a negligible class showing no clear trend, and hence no further assumptions will be posed regarding this category.

10.3 Contextual Frame Trends

We saw that Contextual Frames are optional elements which have the potential of expressing a much greater range of meanings than Subjects express. Because of this, the questions concerning possible trends in the choice of Contextual Frames as writers gain experience rest on far wider ground than those concerning Subjects. Nevertheless, it has been possible to identify four more specific questions motivated by the way in which Contextual Frames started to evolve in the pilot analysis. Each question concerns one of the four Contextual Frame categories, and will be considered in turn.

10.3.1 Evolution of Typical Contextual Frames

One important question concerning Typical Contextual Frames was whether these more frequent and common pre-Subject elements would tend to decrease as writers gained experience. Interestingly, the answer is no. On the contrary, results have shown that there is a tendency for such elements to increase slightly as time goes by. One explanation could be that although Contextual Frames seen as a whole are optional, some Contextual Frame elements, such as conjunctions, for instance, are mostly obligatory: there can be a strong logical component to Contextual Frames which implies that some of them are necessary for the flow of the text and for its organisation.

This is shown by the fact that physics papers as a whole tend to have around half of their Subjects preceded by Contextual Frames, with at least one third of these belonging to the Typical Category. These elements are primarily conjunctions and conjunctive Adjuncts. Results suggest that as researchers gain experience in writing their papers, they tend to increase their use of these more common thematic elements of a 'textual' and 'logical' nature, which are actually necessary for the flow of the text and its organisation.

10.3.2 Evolution of Conventional Contextual Frames

Regarding Conventional Contextual Frames, a class which is composed of Circumstantials without post-modification, the assumption was that there would be little evidence of noticeable trends in the use of these commonly used terms as

scientists gain experience. This assumption holds well when results for the category are looked at as a whole. However, once three different subcategories are distinguished, one significant trend does appear: it shows that experienced researchers increase their use of Location Contextual Frames. More precisely, results suggest that these Location Contextual Frames, by far the most numerous and distinctive[32] subcategory within Conventional Contextual Frames, rise from 10 to 16% with most of the increase occurring in the first seven years of publishing articles. Circumstantials of Cause and Condition represent only about 2% of Conventional Contextual Frames throughout the period, being consistent in showing no change in their use. Matter and Angle show an erratic behaviour which is not significant at the statistical level and blurs results when the category is looked at as a whole.

Here again results suggest that as writers gain experience, they tend to increase their use of Location Contextual Frames in Theme position, which have an important role in enhancing the flow of the text and its organisation.

10.3.3 Evolution of Instantial Contextual Frames

The next question is whether, in a similar way to Instantial Subjects, there is an increase in the use of more complex Instantial Contextual Frames enclosing multiple strands of meaning. Interestingly, the analysis gives no evidence of such an increase. On the contrary, results show a statistically significant decrease in

[32] The qualification of 'distinctive' is used here in the sense that meanings of Location were the

Subcategory 9, the most numerous Instantial subcategory which contains non-finite clauses. The general trend indicates a decrease from 12% to 7%, suggesting that experienced writers will tend to reduce their use of these more complex Contextual Frames. This is further confirmed when looking in what follows at the results of the analysis of Expressive Contextual Frames.

10.3.4 Evolution of Expressive Contextual Frames

The question here centres on whether there is an increase in the use of Expressive Contextual Frames as scientists gain experience as writers. More explicitly, it is important to know whether there is a move towards the use of these types of complex Contextual Frames with added interpersonal strands of meaning. The corpus analysis has shown that there is no such increasing trend. When the class is looked at as a whole, there is no evidence of change. When two subcategories are distinguished, there is a decrease in the most numerous one, Subcategory 10, Circumstantials and clauses with embedded evaluation. More specifically, the trend for Subcategory 10 indicates a steady decline from 15% to 10% as writers gain experience. On the other hand, Subcategory 11 for projecting clauses shows an erratic behaviour with no statistical significance. It is this erratic behaviour which blurs the statistically significant decrease in Subcategory 10 when Expressive Contextual Frames are looked at as a whole.

In the last two cases of Instantial and Expressive Contextual Frames results suggest that as writers gain experience, they will tend to decrease their use of

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most recognisable Circumstantials in the present corpus.

complex and multistranded framing elements. These trends will now be examined in relation with the ones that showed up for Subjects.

10.4 The interplay of thematic elements as writers gain experience

A further look at the evolution of Subjects and Contextual Frames considered jointly can be useful in an endeavour to distinguish relevant patterns of interaction between these two thematic components.

When looking at statistically significant results for Subjects alone, we saw that expert writers tended to shift their choices from Conventional to Instantial Subjects. When looking at these trends for Contextual Frames, we saw that, by contrast, writers shifted their choices from Instantial to Conventional Frames over time.

When looking at results for Subjects and Contextual Frames together, interesting interaction patterns emerge, the main one being the differing behaviours of Instantial wordings according to whether they are in Subject or in Contextual Frame position. These results indicate that as researchers gain experience, they become increasingly capable of moulding the more complex Instantial Subjects needed to express the kind of information they want to pass on to their research community. As Subjects start incorporating rising amounts of complexity, a natural outcome seems to be not to burden the reader with similarly intricate Instantial Contextual Frames. Moreover, experienced researchers appear to opt for concentrating complex meanings, whose best position is in Theme, in Subject

rather than in Contextual Frame position. The corpus analysis indicates that later papers will have of the order of 15% more Instantial Subjects, and 10% fewer Contextual Frames of an Instantial character[33].

Quite the reverse happens for the more commonly used linguistic expressions represented on the one hand by Conventional Subjects, and on the other by Typical and Conventional Contextual Frames. Findings show a decrease in Conventional Subjects of about 10% as writers gain experience, whereas Typical Contextual Frames and Location within Conventional Contextual Frames taken together show an increase of the same order. Results thus suggest that there will be a tendency for more expert writers to make full use of the simpler and probably more necessary Contextual Frames that are crucial for an optimum text flow, and not burden this pre-Subject slot with unnecessarily intricate meanings that could be positioned in Rheme.

Regarding overt interpersonal strands of meaning in thematic position, at first sight results appear to be disappointing. Participant Subjects show an erratic behaviour, where individual choices appear to dominate rather than more general trends focussing on writer experience. The same erratic behaviour is shown in Contextual Frame by the overtly interpersonal Subcategory 11, projecting clauses, of the Expressive Category. Both behaviours could indicate the prevalence of individual choices over more genre specific ones. Such an assumption would need to be supported by further analysis, and opens new avenues for further research on writer choices in the research article.

[33] Here I am referring to a 5% decrease in Subcategory 9, non-finite clauses, plus a 5% decrease in Subcategory 10, Circumstantials and clauses with embedded evaluation.

Moreover, when looking at more hidden strands of interpersonality, the increase in Instantial Subjects and the decrease in Subcategory 10 that groups Circumstantials and clauses with embedded evaluation would point towards the fact that some subtle and covert signs of interpersonality would tend to flow towards Subject. However, this is again a tentative assumption, precisely because of the subtle and covert nature of such meanings, which could profit from future research on writer choices. The next section will present general conclusions and discuss further suggestions for future research.

10.5 Conclusions and suggestions for future research

10.5.1 General Conclusions

The relevance of the present research is that it has provided evidence of differences between first and last physics articles published by researchers actively working within their discourse community. An important feature has been tracing the evolution of the writing expertise of 10 researchers who provided three published research articles each, written during the course of their careers. This longitudinal analysis of an extended corpus allowed trends to become apparent, which would have remained hidden in the case of isolated case studies. The most interesting finding is that Instantial elements, characterised by being multistranded and complex, tend to increase in Subject position with writer experience, whereas these types of wording tend to decrease in Contextual Frame position. Another interesting finding of the present corpus is that contrary to what was initially suggested by the pilot analysis, elements with the strongest interpersonal strand and high overt writer visibility, i.e. Participant Subjects and projecting clauses within Expressive Contextual Frames, do not increase with

experience but rather show erratic behaviour that could be suggestive of a high degree of personal choice.

Particular care was given to studying how representative the extended corpus was and the confidence level of the trends shown by the statistical analysis. An initial pilot study was useful for the formulation of research questions and for showing up problems with the taxonomy of thematic elements. Moreover, it also illustrated the need for an extended analysis of the type undertaken here, in order to be able to generalise results. Nonetheless this modest study of a sample drawn from a single genre not only suggests considerable scope for further research, but also raises fundamental questions about Theme analysis.

10.5.2 Suggestions for further research

10.5.2.1 Raising further questions regarding Theme

Results for Contextual Frame from the present analysis indicate that more experienced writers appear not to utilise multistranded Instantial and Expressive frames, but to signal forthcoming information, sequence of events or changes of topic by simple conjunctions and conjunctive Adjuncts, or by non postmodified Circumstantials of Location. The analysis suggests that when writers gain experience, as these simple Contextual Frames increase, complexity is transferred towards the 'nub of the argument', i.e. towards Subject position. This in turn raises questions about the perceived role of Subject in research articles, and about the possible potential of undertaking an analysis of within-article choices of Subject.

Berry (1996) suggests that the priority meanings that are being enabled by the textual metafunction in pre-Subject position would be interpersonal and 'logical' meanings. For the present corpus it looks as if expert physics writers prioritise logical, or 'transitional' (Berry 1996:46), meanings at the very beginning of the clause, and that interpersonal meanings would be interwoven with other strands of meaning from Subject onwards. Looking in greater depth at Contextual Frame and Subject elements in research articles in the hard sciences might open new avenues of research, which could help towards a better understanding of the elusive logical metafunction and its relation with the experiential metafunction. One interpretation within systemics is that logical meaning is related to construing relations between events, whereas experiential meaning is related to construing the internal relations of events. An important question to explore would be why the 'expert' appears to choose to simplify wordings expressing relations between events, but tends towards incorporating complexity when wording internal relations of events typically in Subject position.

10.5.2.2 Collecting further corpora

Another important step towards consolidating the present research would be to set up a more extensive corpus including case studies of a similar set of researchers, in order to test the results obtained in the present thesis. This further stage of the research would enable the post hoc procedure set up here, in which

the data gathered from the extended analysis was used to refine hypotheses and discuss changes in Theme choices, to move on to a preplanned procedure, where the set of conclusions arrived at here could be tested further.

A further possibility would be to analyse different corpora from other highly internationalised branches of science, such as mathematics, biology, or information technology, and compare the results of such analyses with the present findings. Regarding the analysis of research papers in mathematics, one interesting result that should be pursued further is the one discussed in Chapter 8. It was noticed that more mathematical papers within physics, at the same level of writer expertise, contained comparatively fewer Instantial Subjects. A possible explanation was offered on the basis of the higher degree of formalisation of mathematics. Nevertheless, there still seems to be a trend towards the increase of Instantial Subjects as writers gain experience, a result which would be worthwhile to pursue further. This could lead to simultaneous explorations in writer development and generic differences.

10.5.2.3 Suggestions for research in pedagogical applications

Finally, one of the reasons for studying the ways in which more experienced writers of research articles manage thematic elements is to help novice researchers enter more successfully into the publishing 'arena'. In the author's experience with academic writing workshops, young researchers are often eager to know how their published work compares with that of leaders in their field, not only

regarding results per se, but also regarding the way of presenting them. Researchers publishing their first papers are acutely aware of the importance of mastering optimal writing strategies in a highly competitive publishing arena. Rather than just seeking advice at the editing level, there comes a point when they want to discuss composing processes. A greater focus on thematic elements in general and on Subject in particular can be a very effective way of helping, especially when time is short and the pressures to publish are great.

An outcome of the analysis could thus be to raise researchers' awareness of the different possibilities offered by the Subject and Contextual Frame slots to suit different communicative aims. Devising these Thematic elements could be an important step in giving a more "expert" tone to research articles, where writer choices are especially strategic as they affect the way in which findings are perceived by the research community at large. A step in this direction is the kind of text-based analysis initially used by researchers such as Swales (1981) and Myers (1985), adapted for the purpose of raising awareness on writing expertise. An example is selecting articles, considered as being classics within a given research field, for students to examine regarding the type of Subjects used by expert writers, and how these writers frame their Subjects. One interesting outcome for teachers of English working in research surroundings is that when devising such exercises, applied linguistics becomes an important support for the teaching of language thus providing an illustration of how to bridge the gap pointed out for instance by Posteguillo and Palmer (2000) between theoretical linguistic input and practical methodology in language teaching. Another

interesting outcome for the ESP practitioner is that a dialogue can naturally be established with specialists from other research communities, whose help is often crucial in selecting and analysing relevant texts from their fields.

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APPENDIX I

STEPS IN THE ANALYSIS OF A SAMPLE PAPER

APPENDIX I-A

PAPER F2 AS AN ASCII FILE

This is the electronic form by which physics papers are sent to journals for publication. This has been current practice for the past ten years. For the purpose of the present linguistic analysis, papers published previously had to be scanned from a hard copy. During the scanning process equations and figures get distorted and are lost, which is actually not a problem for the linguistic analysis per se.

```
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\title{Canonical Structure of the Non-Linear $\sigma$-Model in a
Polynomial Formulation}
\author{C. D. Fosco and T. Matsuyama
\footnotemark[1]
\\ \\ University of Oxford\\
Department of Physics, Theoretical Physics\\
1 Keble Road, Oxford OX1 3NP, UK }
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\begin{abstract}
We study the canonical structure of the $SU(N)$ non-linear
$\sigma$-model in a polynomial, first-order representation. The
fundamental variables in this description are a non-Abelian vector
field $L_{\mu}$ and a non-Abelian antisymmetric tensor field
$\theta_{\mu \nu}$, which constrains $L_{\mu}$ to be a `pure
gauge' ($F_{\mu \nu}(L) = 0$) field. The second-class constraints
that appear as a consequence of the first-order nature of the
Lagrangian are solved, and the reduced phase-space variables
explicitly found. We also treat the first-class constraints due to
the gauge-invariance under transformations of the antisymmetric
tensor field, constructing the corresponding most general gauge-
invariant functionals, which are used to describe the dynamics of
the physical degrees of freedom. We present these results in
$1+1$, $2+1$ and $3+1$ dimensions, mentioning some properties of
the $d+1$-dimensional case.  We show that there is a kind of
duality between this description of the non-linear $\sigma$-model
```

and the massless Yang-Mills theory. This duality is further extended to more general first-class systems.

\vskip 2cm
Key words: sigma-model, constraints.
\vskip 0.7cm
\end{abstract}
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\end{titlepage}
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\parskip=3pt
\section{Introduction}
One of the distinctive properties of the non-linear σ-model~\cite{gell}, is that its dynamical variables belong to a non-linear manifold~\cite{zinn}, thus realising the symmetry group in a non-linear fashion~\cite{gasi}. Whence, either the Lagrangian becomes non-polynomial in terms of unconstrained variables, or it becomes polynomial but in variables which satisfy a non-linear constraint. It is often convenient to work in a polynomial or `linearized' representation of the model. By this we mean an equivalent description where the symmetry is linearly realised, although the transformations now act on a different representation space. There is usually more than one way to construct such linearized representations. For example, in the $O(N)$ models, where the field is a N-component vector constrained to have constant modulus, a polynomial representation is constructed simply by introducing a Lagrange multiplier for that quadratic constraint. However, this simplicity is not present in general because the constraints required to define the manifold can be much more complex, like in the $SU(N)$ groups.

In references~\cite{town,cart} a polynomial representation of the non-linear σ-model was introduced; let us briefly explain it for the $SU(N)$ model in d+1 dimensions.

The usual presentation~\cite{slav} of this model is in terms of a $SU(N)$ field $U(x)$, with Lagrangian density
\begin{equation}
{\cal L} \,=\, \frac{1}{2} g^{d-1} tr(\partial_{\mu}U^{\dagger} \partial^{\mu}U)\;\;,
\label{01}
\end{equation}
where g is a coupling constant with dimensions of mass (the constant f_{π} in its application to Chiral Perturbation Theory in 3+1 dimensions). The polynomial description~\cite{cart} of this model is constructed in terms of a non-Abelian ($SU(N)$) vector field L_{μ} plus a non-Abelian antisymmetric tensor field $\theta_{\mu \nu}$\footnote{ To avoid the proliferation of indices, we frequently work in terms of the {\em dual} of $\theta_{\mu \nu}$, which in $1+1$ is a pseudo-scalar, in $2+1$ a pseudovector, etcetera.} with the Lagrangian density
\begin{equation}
{\cal L} \,=\, \frac{1}{2} g^2 L_{\mu} \cdot L^{\mu} + g \, \theta_{\mu \nu} \cdot F^{\mu \nu}(L)
\label{02}
\end{equation}
where the fields L_{μ} and $\theta_{\mu \nu}$ are defined by their components in the basis of generators of the adjoint representation of the Lie algebra of $SU(N)$; i.e., $L_{\mu}(x)$

is a vector with components $ L_{\mu}^a, a = 1,\cdots , N^2 - 1$, and analogously for $\theta_{\mu \nu}$. The components of $F_{\mu \nu}$ in the same basis are: $F_{\mu \nu}^a (L) = \partial_{\mu} L_{\nu}^a - \partial_{\nu} L_{\mu}^a + g^{\frac{3-d}{2}} f^{a b c} L_{\mu}^b L_{\nu}^c $. The dots mean $SU(N)$ scalar product, for example: $L_{\mu} \cdot L^{\mu} = \sum_{a = 1}^{N^2 -1} L_{\mu}^a L^{\mu}_a$. The d-dependent exponents in the factors of g are chosen in order to make the fields have the appropriate canonical dimension for each d.

The Lagrange multiplier $\theta_{\mu \nu}$ imposes the constraint $F_{\mu \nu}(L) =0$, which is equivalent~\cite{itzy} to $L_{\mu} = g^{\frac{d -3}{2}} U\partial_{\mu} U^{\dag}$, where U is an element of $SU(N)$. When this is substituted back in (\ref{02}), (\ref{01}) is obtained \footnote{For a complete derivation of the equivalence between the theories defined by (\ref{01}) and (\ref{02}) within the path integral framework, see ref.~\cite{cart}.}. This polynomial formulation could be thought of as a concrete Lagrangian realization of the Sugawara theory of currents~\cite{suga}, where all the dynamics is defined by the currents, the energy-momentum tensor, and their algebra. Indeed, L_{μ} corresponds to one of the conserved currents of the non-polynomial formulation, due to the invariance of ${\cal L}$ under global (left) $SU(N)$ transformations of $U(x)$. The energy-momentum tensor for (\ref{02}) is indeed a function of L_{μ} only:

$$
T^{\mu \nu} \;=\; g^2 (L^{\mu} \cdot L^{\nu} - \frac{1}{2} g^{\mu \nu} L^{2}) \;.
$$

One can easily relate amplitudes with external legs of the field L_{μ} to the corresponding pions' scattering matrix elements, as shown in ref.~\cite{slav}. It is also possible to relate off-shell Green's functions of the field U to the ones of the field L_{μ}, although this relation is non-local. As

$$
L_{\mu} \,=\, g^{\frac{d-3}{2}} U\partial_{\mu} U^{\dag} \Rightarrow D_{\mu}U =0, \;\; D_{\mu} \,\equiv \, \partial_{\mu} + g^{\frac{3-d}{2}} L_{\mu} \;, \label{03}
$$

then U can be obtained at the point x by parallel transporting its value at spatial infinity, which we fix to be equal to the unit matrix\footnote{We identify (as usual) all the points at spatial infinity.}:

$$
U(x)\,=\, {\cal P} \exp [- g^{ \frac{3-d}{2} }\int_{C_x} dy^{\mu} L_{\mu} (y)], \label{04}
$$

where ${\cal P}$ is the path-ordering operator~\cite{itzy}, and the line-integral in the exponent is along a curve C_x, a regular path starting at spatial infinity, and ending at x. The condition $F_{\mu\nu}=0$ guarantees that U is in fact invariant under deformations of C_x which leave its endpoints unchanged. We can also construct products of two or more fields in a similar way, for example

\begin{equation}
U(x_2) \, U^{-1} (x_1) \;=\;{\cal P} \exp [-
g^{ \frac{3-d}{2} } \int_{C_{x_1 \to x_2}}
dy_{\mu}
L^{\mu} (y)] \;,
\label{05}
\end{equation}
where $C_{x \to y}$ is a continuous path from x_1 to x_2. This shows how U-field correlation functions can in principle be calculated using Lagrangian (\ref{02}); one has to evaluate, for example, the Wilson line (\ref{05}) in the theory defined by (\ref{02}).

The classical equations of motion for the Lagrangian (\ref{02})are
\begin{eqnarray}
L^{\nu} (x) &=& \frac{1}{g} D_{\mu} \theta^{\mu \nu}(x)
\;,\nonumber\\
F^{\mu \nu} (L) &=& 0 \;.
\label{06}
\end{eqnarray}
Taking the covariant divergence on both sides of the first equation of motion, and using the second one, one gets
\begin{equation}
\partial \cdot L (x) \,=\, 0 \;.
\label{07}
\end{equation}
Inserting $L_{\mu} = g^{\frac{3-d}{2}} U\partial_{\mu} U^{\dagger}$ in (\ref{07}), it yields the equations of motion for the usual non-polynomial Lagrangian (\ref{01}). Note that the solutions of (\ref{06}) will, in general, contain arbitrary functions of the time. If we know a solution, performing on it the transformation:
\begin{eqnarray}
\theta_{\mu \nu}(x) &\to& \theta_{\mu \nu} (x) + \delta_{\omega} \theta_{\mu \nu} (x) \nonumber\\
\delta_{\omega} \theta_{\mu \nu} (x) &=& D^{\rho} \omega_{\rho \mu \nu}(x)
\;,
\label{08}
\end{eqnarray}
where $\omega_{\rho \mu \nu}(x)$ is an arbitary completely antisymmetric tensor field, will produce another solution, because $D_{\mu} \delta_{\omega} \theta^{\mu \nu}$ vanishes as a consequence of the Bianchi identity for L_{μ}\footnote{This kind of symmetry also appears when considering the dynamics of a two-form gauge field, see for example references~\cite{anti}}. Obviously d must be larger than one in order to this transformation be well defined, since at least three different indices are needed to have a Bianchi identity. This degeneracy in the equations of motion is due to the gauge invariance of the action under the transformations (\ref{08}).

This gauge-invariance makes the quantization of the model interesting, and it will allow us to discuss some properties of the non-linear σ-model from the (unusual) point of view of gauge systems. The Hamiltonian formulation of the model possesses a rich structure, since there are second-class constraints (${\cal L}$ is first-order), first-class constraints (for $d > 1$), and moreover they are reducible for $d > 2$.

The structure of the paper is as follows: In section 2 we discuss the Hamiltonian formulation of the $1+1$, $2+1$ and $3+1$ models, following the Dirac algorithm~\cite{dira}. In section 3 we construct the general gauge invariant functionals for the transformations generated by the first-class constraints found in section 2, and in section 4 we apply the Dirac's brackets method to the second-class system formed by the first-class constraints plus some canonical gauge-fixing conditions. In section 5 we present our conclusions.

In Appendix A we discuss a duality relationship between first-class systems, which generalizes a property we discuss for the $2+1$-dimensional model.

\section{Hamiltonian formalism and constraints}

\subsection{$1+1$ dimensions}

>From Section 1, the polynomial Lagrangian in $1+1$ dimensions becomes
\begin{equation}
{\cal L} \;=\; \frac{1}{2} g^2 L_{\mu} L^{\mu} + \frac{1}{2} \, g \, \theta \, \epsilon_{\mu \nu} F^{\mu \nu} (L)
\label{11}
\end{equation}
where θ is a pseudoscalar field. It is evident that there is no gauge symmetry in this case. Thus there will not be first-class constraints in the Hamiltonian formulation. However, there are second-class constraints, because ${\cal L}$ is of first-order in the derivatives. This property will also appear in higher dimensions, so we will only discuss it in some detail for this case. To start with, we rewrite (\ref{11}) in a more explicit form
\begin{equation}
{\cal L} \,=\, \frac{1}{2} g^2 L_0^a L_0^a - \frac{1}{2} g^2 L_1^a L_1^a + g \theta^a \partial_0 L_1^a - g \theta^a \partial_1 L_0^a +
g^2 \theta^a f^{a b c} L_0^b L_1^c \;.
\label{12}
\end{equation}
Next we define the canonical momenta, where the primary constraints appear:
\begin{eqnarray}
{\pi}_0^a (x) &\equiv& \frac{ \partial {\cal L} }{\partial (\partial_0 L_0^a)}
\approx 0
\nonumber\\
{\pi}_1^a &\equiv& \frac{ \partial {\cal L} }{\partial (\partial_0 L_1^a)}
\approx g \theta^a (x)
\nonumber\\
\pi^a_{\theta} (x) &\equiv& \frac{ \partial {\cal L} }{\partial (\partial_0 \theta^a)}
\approx 0
\label{15}
\end{eqnarray}
and the canonical Hamiltonian becomes

\begin{equation}
H \,=\, \int d {\bf x} [- \frac{1}{2} g^2 L_0^a L_0^a +
\frac{1}{2} g^2
L_1^a L_1^a - g L_0^a {(D_1 \theta)}^a] \;,
\label{16}
\end{equation}
where
\begin{equation}
{(D_1 \theta)}^a \,=\, \partial_1 \theta^a + g f^{a b c} L_1^b
\theta^c
\;.
\label{17}
\end{equation}

The `total' Hamiltonian is constructed as usual, adding to (\ref{16}) a Lagrange multiplier term for each of the primary constraints (\ref{15}). Following the Dirac's algorithm one more constraint is obtained:
\begin{equation}
g L_0^a (x) \approx - {(D_1 \theta)}^a (x)
\label{18}
\end{equation}
and the Lagrange multipliers become fully determined. The full set of (primary plus secondary) constraints is second-class, and its particular form allows us to eliminate the canonical pairs of L_0^a and θ^a, thus effectively eliminating the associated degrees of freedom. The Dirac bracket becomes equal to the Poisson bracket for the remaining degrees of freedom. The resulting Hamiltonian is
\begin{equation}
H \;=\; \int d x [\frac{1}{2 g^2} D_1 \pi_1 \cdot D_1 \pi_1 \,+
\frac{1}{2} g^2 L_1 \cdot L_1]\;,
\label{19}
\end{equation}
with canonical brackets between the L_1^a's and their momenta π_1^a. Thus these two variables become symplectic coordinates on the reduced phase-space, or constraint surface.

\subsection{$2+1$ dimensions}
The polynomial Lagrangian in this case becomes,
\begin{equation}
{\cal L} \;=\; \frac{1}{2} g^2 L_{\mu} \cdot L^{\mu} + \frac{1}{2}
\, g \, \theta_{\mu} \,\cdot \epsilon^{\mu \nu \lambda} F_{\nu
\lambda} (L).
\label{121}
\end{equation}
The constraint algorithm\footnote{The full details of the application of the Dirac algorithm to this system will be presented elsewhere.} produces the $2+1$ analogous of the second-class constraints we showed in Section 1, allowing us to eliminate the 0-component of L_{μ} and all the components of θ_{μ}. However, there will remain a set of first-class constraints
\begin{equation}
G^a (x) \;=\; \frac{1}{2} \epsilon_{j k} F_{j k}^a \; \approx \;
0\;,
\label{122}
\end{equation}
with the first-class Hamiltonian

\begin{equation}
H \;=\; \int d^2 x [\frac{1}{2 g^2} D_j \pi_j \cdot D_k \pi_k \,
+ \,
\frac{1}{2} g^2 L_j \cdot L_j]\;.
\label{123}
\end{equation}
They satisfy the algebra
\begin{eqnarray}
\{ G^a (x) , G^b (y) \} &=& 0 \nonumber\\
\{ H , G^a (x) \} &=& V^{a b} G^b (x) \nonumber\\
V^{a b} &\equiv& g^{- \frac{3}{2} } f^{a c b} {(D_j \pi_j)}^c (x).
\label{124}
\end{eqnarray}

Now we show in what sense we can relate the massless Yang-Mills theory to the non-linear σ-model in this formulation. The $SU(N)$ Yang-Mills theory is defined by the Lagrangian
\begin{equation}
{\cal L}_{YM} \;=\; - \frac{1}{4} F_{\mu \nu}(L) \cdot F^{\mu \nu}
(L) \;,
\label{125}
\end{equation}
which in the temporal gauge gives rise to the canonical Hamiltonian
\begin{equation}
H \;=\; \int d^2 x [\frac{1}{2} \pi_j \cdot \pi_j + \frac{1}{4}
F_{j k} \cdot F_{j k}] \;,
\label{126}
\end{equation}
and the first-class constraints (`Gauss' laws'):
\begin{equation}
H_a(x) \;=\; (D_j \pi_j)_a(x) \approx 0 \;,
\label{127}
\end{equation}
which satisfy the $SU(N)$ algebra
\begin{equation}
\{ H_a (x) , H_b (y) \} \;=\; \delta (x-y) f_{a b c} H_c (x) \;.
\label{128}
\end{equation}
Note that (\ref{126}) can be rewritten as
\begin{equation}
H \;=\; \int d^2 x [\frac{1}{2} \pi_j \cdot \pi_j + \frac{1}{2}
G \cdot G] \;,
\label{129}
\end{equation}
where the G_a's are the ones defined in (\ref{122}). We then see that the first-class systems corresponding to the Yang-Mills model and the non-linear σ-model can be related by: 1) Interchanging the constraints:
\begin{equation}
H_a (x) \leftrightarrow G_a (x)\;,
\label{130}
\end{equation}
and 2) Interchanging L_j by $\frac{1}{g} \pi_j$ in the non-derivative terms in the Hamiltonian. The generalization of this mapping is constructed in Appendix A.

\subsection{$3+1$ dimensions}

After eliminating the second-class constraints, one obtains a first-class Hamiltonian which looks exactly like the one of the $2+1$-dimensional case:
\begin{equation}
H \;=\; \int d^3 x [\frac{1}{2 g^2} D_j \pi_j \cdot D_k \pi_k \, + \,
\frac{1}{2} g^2 L_j \cdot L_j]\;,
\label{131}
\end{equation}
and the set of first-class constraints
\begin{equation}
G_j^a (x) \;=\; \frac{1}{2}\epsilon_{j k l} F_{k l}^a (x) \approx 0
\;.
\label{132}
\end{equation}
Although the system seems to be the obvious generalization of the $2+1$-dimensional one, there is an essential difference: The constraints (\ref{132}) are not all independent, but verify the Bianchi identity:
\begin{equation}
(D_j G_j)^a (x) \;=\; 0 \;\;,\;\; \forall a \;.
\label{133}
\end{equation}
This implies that the set of constraints is reducible, containing only two independent functions. The counting of degrees of freedom then gives 1 for the number of physical dynamical variables ($1 =
3 - 2$).
We mention that the elimination of the second-class constraints applies in a similar way to the general d-dimensional case, and that the Hamiltonian and constraints are the obvious generalizations of (\ref{131}) and (\ref{132}), respectively. Due to the existence of the Bianchi identity in general, the number of independent constraints in an arbitrary dimension is just enough to kill $d-1$ out of the d degrees of freedom in H, leading to only one physical variable, as it should be for a model which describes the dynamics of a scalar field.

\section{Gauge invariant functionals}
Gauge invariant functionals\footnote{We assume the denomination `gauge-invariant' to mean {\em on-shell} gauge invariance, i.e., the gauge-invariant functionals are invariant on the constraint surface.} are important from both the classical and quantum mechanical points of view. Classically, a complete set of gauge invariant functionals and their equations of motion completely determines the dynamics of the observable, i.e., {\em physical} degrees of freedom. In Quantum Mechanics, Dirac's method for first-class constraints defines the `physical' subspace of the complete Hilbert space as the one whose state vectors are annihilated by the first-class constraints, i.e., the gauge-invariant ones. In the Schroedinger representation, the physical subspace consists of gauge invariant functionals of the fields.

To construct the gauge invariant functionals, we make use of the concept of gauge invariant projection, defined as follows: Let $I\,=\,I[\pi,L]$ be an arbitrary functional of the phase-space fields. Then its gauge-invariant projection ${\cal P}(I)[\pi,L]$ is defined by:

\begin{equation}
{\cal P}(I) [\pi,L] \;=\; \frac{1}{{\cal N}}
\int {\cal D} \omega \, I [\pi^{\omega} , L]\;,
\label{21}
\end{equation}
where π^{ω} is the gauge-trasnformed of π by the gauge group element $\omega (x)$ (for example, in $2+1$ dimensions, $\pi_j^{\omega} = \pi_j + \epsilon_{j k} D_k \omega$) and the functional integration is over all the possible configurations for ω. The normalization factor ${\cal N}$ is just the volume of the gauge group: ${\cal N} \,=\, \int {\cal D} \omega$. It is then easy to see that the gauge invariant projection of an arbitrary functional is indeed gauge invariant:
\begin{equation}
{\cal P}(I) [\pi^{\omega} , L] \;=\; {\cal P}(I) [\pi , L] \;,
\label{22}
\end{equation}
and that ${\cal P}$ is a linear projection operator:
\begin{eqnarray}
{\cal P} (\lambda_1 I_1 + \lambda_2 I_2) &=& \lambda_1 {\cal P} (I_1) +
\lambda_2 {\cal P}(I_2) \;,
\nonumber\\
{\cal P}^2 &=& {\cal P} \;\;,\;\; \forall I \;.
\label{23}
\end{eqnarray}
A functional F is gauge invariant if and only if ${\cal P}(F) = F$. This can be shown to be equivalent to saying that F belongs to the image of ${\cal P}$. We then construct the most general gauge-invariant functional by applying ${\cal P}$ to an arbitrary functional.

In $2+1$ dimensions, we further decompose the momentum as
\begin{equation}
\pi_j (x) \;=\; D_j \alpha (x) + \epsilon_{j k} D_k \beta (x) \;,
\label{24}
\end{equation}
(where α and β are scalar and pseudoscalar, respectively) to show that
\begin{eqnarray}
{\cal P}(I)[\pi,L] &=& {\cal P}(I) [\alpha, \beta, L] \;=\;
\frac{1}{{\cal N}} \int {\cal D} \omega \; I[D_j \alpha +
\epsilon_{j k}
D_k (\beta + \omega) , L] \nonumber\\
&=& I[\alpha, 0, L]
\label{25}
\end{eqnarray}
where the last line was obtained by performing the shift $\omega \to \omega - \beta$. (\ref{25}) shows that any gauge invariant functional is independent of β; the reciprocal is immediate. The conclusion can be put as follows: The general gauge invariant functional depends arbitrarily on L, an on π only through the combination $D_j \pi_j$.

This result is generalizable to $3+1$ dimensions. F is shown to depend only on $D_j \pi_j$ and L_j, by using the same argument as in the $2+1$ case. The decomposition of π_j is now
\begin{equation}
\pi_j (x) \;=\; D_j \alpha (x) + \epsilon_{j k l} D_k \beta_l (x)

\;,
\label{26}
\end{equation}
and the β dependence is removed as before by a shift in ω. The only difference appears in the actual construction of the projection operator, which appears to be ill-defined at first sight. This is so because the gauge transformations in $d = 3$:
\begin{equation}
\pi^{\omega}_j \;=\; \pi_j + \epsilon_{j k l} \, D_k \, \omega_l \;,
\label{27}
\end{equation}
are invariant under $\omega_j(x) \to \omega_j(x) + D_j \lambda (x)$, for any λ. This produces an infinite factor when one integrates over ω in the definition (\ref{21}) of ${\cal P}(I)$. Of course, this factor is also present in ${\cal N}$, but to explicitly cancel them on needs to `fix the gauge' for the integration over $\omega$. A convenient way to do that is by using the Faddeev-Popov trick, which gives the `gauge fixed' projector
\begin{eqnarray}
{\cal P}(I)[\pi,L] &=& \frac{1}{\int {\cal D} \omega \det M_f [\omega]
\delta [f(\omega)] } \nonumber\\
&\times& \int {\cal D} \omega \det M_f [\omega] \delta [f(\omega)] I[D_j \alpha + \epsilon_{j k l} D_k \omega_l] \;,
\label{28}
\end{eqnarray}
where $M_f [\omega]= \frac{\delta}{\delta \lambda}f(\omega^{\lambda})$. We have seen that the gauge invariant functionals depend on $D_j \pi_j$ and L_j (the result is indeed true in any number of dimensions). However, there is still a degree of redundancy in this description because one is interested only in gauge invariant functions {\em on-shell}, i.e., on the surface $F_{j k} (L) = 0$. Thus we do not need the full L_j, but only its restriction to the constraint surface. As it was shown in ref.~\cite{slav}, it is possible to solve that kind of equation using a perturbative approach. The main result we need to recall is that that perturbative expansion allows one to express L_j as a function of the scalar $\partial_j L_j$ only. Then we obtain a more symmetrical description in terms of the gauge-invariant, scalar variables:
\begin{equation}
(D_j \pi_j)^a (x) \;\;,\;\; (D_j L_j)^a (x) = \partial_j L_j^a (x)\;.
\label{29}
\end{equation}
Their equations of motion link each other:
\begin{eqnarray}
\frac{\partial}{\partial t} (D_j \pi_j) &=& - g^2 \partial_j L_j
\nonumber\\
\frac{\partial}{\partial t} (\partial_j L_j) &=& - g^{-2}
\partial_j D_j
(D_k \pi_k) \nonumber\\
F_{j k} (L) &\approx& 0\;,
\end{eqnarray}
(where we have included the constraints).They imply the second order equations

\begin{eqnarray}
(\partial_t^2 - \partial_j D_j) D_k \pi_k &=& 0 \nonumber\\
(\partial_t^2 - \partial_j D_j) \partial_k L_k &=& 0,
\label{30}
\end{eqnarray}
which show the scalar particle nature of the (only) physical degree of freedom. Let us consider in more detail the issue of {\em static} solutions in $3+1$ dimensions. In this situation, (39) reduces to
\begin{eqnarray}
\partial_j L_j &=& 0 \;\;\;, \;\;\; F_{j k} \;\approx\; 0
\nonumber\\
\partial_j D_j (D_k \pi_k) &=& 0 \;.
\label{31}
\end{eqnarray}
The first two equations in (\ref{31}) are equivalent to
\begin{equation}
L_j \;=\; U\partial_j U^{\dagger} \;\; , \;\; \partial_j L_j
\,=\,0
\;.
\label{32}
\end{equation}
They are exactly the set of equations one gets when considering the Gribov problem~\cite{grib}(for the Yang-Mills theory) in the Coulomb gauge, on the orbit of the trivial configuration ($L_j =0$). It is well known that there are more solutions than just the trivial one, in particular, one obtains the `fermionic' configurations of the Skyrme model\footnote{The stabilizing term can be added without changing the canonical structure of the model.}, which verify
\begin{equation}
n \;=\; - \frac{1}{24 \pi^2} \int d^3 x \;\epsilon_{j k l} \;
tr (L_j L_k L_l)\;=\; \pm \frac{1}{2} \;.
\label{33}
\end{equation}
Once a particular solution of (\ref{33}) is obtained, it can be inserted in the last equation of (\ref{31}) to get an equation for π. Note that the momenta should then satisfy
\begin{equation}
D_j \pi_j \;=\; f_0 \;,
\label{34}
\end{equation}
where f_0 is a zero mode of the operator $\partial_j D_j$ (of course, the trivial solution $\pi_j = 0$ is included). For each Gribov solution L_j, there will be a non-trivial zero mode for this operator, and then a non-zero solution for the momenta. These solutions can be compared to the static solutions of the usual non-polynomial formulation. To do that we must regain the field L_0, which was eliminated by using the second-class constraints. That is very simple, since in fact L_0 is equal to a constant times $D_j \pi_j $, and then (\ref{34}) implies
\begin{equation}
L_0 \; =\; f_0 \;.
\label{35}
\end{equation}
So the family of static solutions in the polynomial version seems to be larger than in the usual treatment. Indeed, as $L_0 = U \partial_0 U^{\dagger}$, a non-zero L_0 implies that there is a

time-dependence for U. Note, however, that such configurations contribute to the energy in an amount:
\begin{equation}
E(L_0) \;=\; \frac{1}{2} g^2 \int d^3 x {[f_0]}^2 \;,
\label{36}
\end{equation}
which is proportional to the norm of the zero mode, and then the minimum energy will correspond to the trivial configuration $L_0 =0$.
A simple example of a configuration with $L_0 \neq 0$ is:
\begin{eqnarray}
{\tilde L}_j ({\bf x} , t) &=& \exp (i h t) L_j({\bf x}) \exp (-i h t)
\nonumber\\
{\tilde L}_0 (t) &=& h \;,
\label{37}
\end{eqnarray}
where h is a hermitian (constant) traceless matrix, and $L_j({\bf x})$ satisfies (\ref{32}). Thus for (\ref{37}), $E(L_0)\,=\,\frac{1}{2} g^2 tr(h^2) \int d^3 x$, which is divergent for infinite volume.

\section{Dirac's brackets method}
As an alternative to the previous approach, we apply here the `Dirac's brackets method' to the treatment of the first-class constraints in the $2+1$ model (it can however be straightforwardly generalized to the $d+1$ model). It consists in constructing the Dirac's brackets for the set of {\em second-class} constraints containing all the original first-class constraints plus a suitable set of gauge fixing conditions. We choose the canonical gauge fixing functions:
\begin{equation}
\chi^a (x) \;=\; \pi_2^a (x) \;=\; 0 \;.
\label{ss1}
\end{equation}
The basic ingredient to calculate the Dirac's brackets is the Poisson bracket between χ^a and $G^a (x)$: $\{ \chi^a (x) , G^b (y) \} = (D_1)^{a b} \delta ({\bf x} - {\bf y}) $.>From this it follows that the only non-trivial Dirac's brackets between canonical variables are
\begin{eqnarray}
\{ L_1^a (x) , \pi_1^b (y) \}_D &=& \delta_{a b} \delta ({\bf x} - {\bf y})
\;,\nonumber\\
\{ L_2^a (x) , \pi_1^b (y) \}_D &=& \langle x,a\mid D_1^{-1} D_2 \mid y,b \rangle \;.
\label{ss2}
\end{eqnarray}
The second one is a complicated non-local function. It is more convenient to take advantage of the results of the previous section to work with L_j and $D_1 \pi_1$. Then the Dirac brackets become local
\begin{eqnarray}
\{ L_1^a (x) , (D_1 \pi_1)^b (y) \}_D &=& - D_1^{a b} \delta ({\bf x}-
{\bf y})
\nonumber\\
\{ L_2^a (x) , (D_1 \pi_1)^b (y) \}_D &=& - D_2^{a b} \delta ({\bf x} -

```
{\bf y} ) \;.
\label{ss3}
\end{eqnarray}

\section{Conclusions}
The polynomial formulation (\ref{02}) has an interesting canonical
structure. Some of its properties are:
\begin{description}
\item The system has second-class constraints which can be solved
explicitly for some coordinates in terms of the others. This
leaves the  canonical pairs associated to the spatial components
of a  non-Abelian vector field only.
\item For $d>1$  there remain first-class constraints which  form
an Abelian algebra. They, and  the first-class Hamiltonian have
essentially the same structure in any number of dimensions.
However, for $d>2$, the constraints are reducible. The number of
independent constraints is just enough to leave only one physical
degree of freedom.
\item These first-class systems can be regarded as `duals' of the
Yang-Mills model in the temporal gauge, in the sense that  the
constraints in one of the systems are non-trivial gauge invariant
functions in the other. This duality can be generalized to a
greater class of first-class systems.
\item We also constructed the most general gauge invariant
functional explicitly. Note that the Gauss-law constraints of the
dual Yang-Mills system appear here as (non-trivial) gauge
invariant objects, verifying the general property discussed in the
Appendix.
\end{description}

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\appendix
\section*{Appendix A: A duality transformation for first-class
systems}
The kind of `duality' that exists between the massless Yang-Mills
theory and the polynomial version of the non-linear $\sigma$-model
is a particular case of a more general concept, which we define in
this Appendix. Let us consider a constrained dynamical system
defined on a phase-space of coordinates $q_j, p_j, \,\,\, j=1
\cdots N$, with first-class Hamiltonian $H$ and a complete set of
irreducible first-class constraints  $G_a \approx 0 , \,\,\, a=1,
\cdots ,N$. We assume that the first-class constraints satisfy the
closed algebra
\begin{equation}
\{ G_a , G_b \} \;=\; g_{a b c} (q,p) \, G_c
\label{a1}
\end{equation}
and regarding the Hamiltonian, we impose on it the requirement of
having the structure
\begin{equation}
```

```
H \; = \; \frac{1}{2}\,\, F_a (q,p) \, F_a (q,p)
\label{a2}
\end{equation}
```
where the functions $F_a (q,p),\,\,\, a=1, \cdots ,N$ verify the relations

```
\begin{eqnarray}
\{ F_a , F_b \} &=& f_{a b c} (q , p) \,\, F_c \nonumber\\
\{ G_a , F_b \} &=& {\lambda}_{a b c} (q , p) \,\, F_c
\label{a3}
\end{eqnarray}
```
and λ is completely antisymmetric with respect to the last two indices. This implies that the Poisson bracket of H and each of the G_a's will be {\em strongly} equal to zero, what is stronger than what we need in a general first-class system. Indeed, Equations (\ref{a2}) and (\ref{a3}) select among all the possible first-class systems the class which admit a duality of the kind we are going to define.

The associated dual first-class system is defined on the same phase-space, and its Hamiltonian and constraints (denoted with a tilde) are defined by

```
\begin{eqnarray}
{\tilde H} \,&=&\, \frac{1}{2} \,\, G_a \, G_a \nonumber\\
{\tilde G}_a \,&=&\, F_a \, \approx \, 0 \;,
\label{a4}
\end{eqnarray}
```
where F_a and G_a are the ones introduced in (\ref{a1}), (\ref{a2}) and (\ref{a3}). We then verify that the new system is also first-class, since

```
\begin{eqnarray}
\{ {\tilde G}_a , {\tilde G}_b \} &=& {\tilde g}_{a b c} (q , p)
\,\,
{\tilde G}_c \nonumber\\
\{ {\tilde G}_a , {\tilde H} \} &=& V_{a b} (q , p) \,\, {\tilde
G}_b
\;,
\label{a5}
\end{eqnarray}
```
where:

```
\begin{eqnarray}
{\tilde g}_{a b c } (q,p) &=& f_{a b c} (q,p) \nonumber\\
V_{a b} (q,p)  &=& \lambda_{a b c}(q,p) \,\, G_c (q,p) \;.
\label{a6}
\end{eqnarray}
```
Thus evidently this mapping leaves the first-class nature of the system invariant. Note however, that the irreducibility of the new constraints is by no means guaranteed. That will depend upon the particular form of the F_a's. An interesting property of the new system is that, because of (\ref{a3}),

```
\begin{equation}
\{ G_a , {\tilde G_b} \} \; \approx \; 0 \;\; \forall a, b \; ,
\label{a7}
\end{equation}
```
which proves that the G_a's constitute a set of M independent gauge invariant functions, which is a very helpful property when one wants to study the classical or quantal dynamics of the system.

```
Note that the transformation we defined is not necessarily
involutive; to guarantee that we would need a completely
antisymmetric $\lambda_{a b c}$ in Equation (\ref{a3}).

The Hamiltonian (\ref{a2}) resembles the one of the Yang-Mills
system, except for the absence of the term quadratic in the
canonical momenta. We did not include this, neither the
corresponding one in the dual, to keep the discussion as general
as possible. As they are gauge invariant by themselves, their
presence or not do not alter the essence of the discussion.

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APPENDIX I-B

SUBJECT ANALYSIS OF PAPER F2

Fosco C. and Matsuyama T. 1995 Canonical structure of the non-linear σ-Model in a polynomial formulation *Progress in Theoretical Physics* 93, 441 (1995)

CONTEXT	SUBJECT	PROCESS	DEVELOPMENT
INTRODUCTION			
One of the distinctive properties of the non-linear σ-model~\cite{gell}is that	its dynamical variables Conventional	belong to	a non-linear manifold~\cite{zinn}, thus realising the symmetry group in a non-linear fashion~\cite{gasi}.
Whence, either	the Lagrangian Conventional	becomes	non-polynomial in terms of unconstrained variables,
or	it Conventional	becomes	polynomial but in variables which satisfy a non-linear constraint.
	It InstContext	is	often convenient to work in a polynomial or `linearized' representation of the model.
By this	we Participant	mean	an equivalent description where the symmetry is linearly realised, although the transformations now act on a different representation space.
	There Conventional	is	usually more than one way to construct such linearized representations.
For example, in the $O(N)$ models, where the field is a N-component vector constrained to have constant modulus,	a polynomial representation Conventional	is constructed	simply by introducing a Lagrange multiplier for that quadratic constraint.
However,	this simplicity Instantial - Context - Anaphora	is	not present in general because the constraints required to define the manifold can be much more complex, like in the $SU(N)$ groups.
In references ~\cite{town,cart}	a polynomial representation of the non-linear σ-model Conventional	was introduced;	
	let us Participant	briefly explain	it for the $SU(N)$ model in d+1 dimensions.
	The usual	is	in terms of a $SU(N)$ field

	presentation~\cite{slav} of this model Instantial		$U(x)$, with Lagrangian density \begin{equation} where g is a coupling constant with dimensions of mass (the constant f_{π} in its application to Chiral Perturbation Theory in 3+1 dimensions).
	The polynomial description~\cite{cart} of this model Conventional	is constructed	in terms of a non-Abelian ($SU(N)$) vector field L_{μ} plus a non-Abelian antisymmetric tensor field $\theta_{\mu \nu} with the Lagrangian density \begin{equation} where the fields L_{μ} and $\theta_{\mu \nu}$ are defined by their components in the basis of generators of the adjoint representation of the Lie algebra of $SU(N)$; i.e., $L_{\mu}(x)$ is a vector with components $ L_{\mu}^a, a = 1,\cdots , N^2 - 1$, and analogously for $\theta_{\mu \nu}$.
	The components of $F_{\mu \nu}$ in the same basis Instantial	are:	$F_{\mu \nu}^a (L) = \partial_{\mu} L_{\nu}^a - \partial_{\nu} L_{\mu}^a + g^{\frac{3-d}{2}} f^{a b c} L_{\mu}^b L_{\nu}^c $.
	The dots Conventional	mean	$SU(N)$ scalar product, for example: $L_{\mu} \cdot L^{\mu} = \sum_{a = 1}^{N^2 -1} L_{\mu}^a L^{\mu}_a$.
	The d-dependent exponents in the factors of g Instantial	are chosen	in order to make the fields have the appropriate canonical dimension for each d.
	The Lagrange multiplier $\theta_{\mu \nu}$ Conventional	imposes	the constraint $F_{\mu \nu}(L) =0$, which is equivalent~\cite{itzy} to $L_{\mu} = g^{\frac{d - 3}{2}} U\partial_{\mu} U^{\dag}$, where U is an element of $SU(N)$.
When this is substituted back in (\ref{02}),	(\ref{01}) Conventional	is obtained.	
	This polynomial formulation	could be	thought of as a concrete Lagrangian realization of

	Conventional		the Sugawara theory of currents~\cite{suga}, where all the dynamics is defined by the currents, the energy-momentum tensor, and their algebra.
Indeed,	L_{μ} Conventional	corresponds to	one of the conserved currents of the non-polynomial formulation, due to the invariance of ${\cal L}$ under global (left) $SU(N)$ transformations of $U(x)$.
	The energy-momentum tensor for (\ref{02}) Conventional	is	indeed a function of L_{μ} only: \begin{equation}
	One Participant	can easily relate	amplitudes with external legs of the field L_{μ} to the corresponding pions' scattering matrix elements, as shown in ref.~\cite{slav}.
	It Instantial - Context	is	also possible to relate off-shell Green's functions of the field U to the ones of the field L_{μ}, although this relation is non-local. As \begin{equation} then U can be obtained at the point x by parallel transporting its value at spatial infinity, which we fix to be equal to the unit matrix: \begin{equation} where ${\cal P}$ is the path-ordering operator~\cite{itzy}, and the line-integral in the exponent is along a curve C_x, a regular path starting at spatial infinity, and ending at x.
The condition $F_{\mu\nu}=0$ guarantees that	U Conventional		is in fact invariant under deformations of C_x which leave its endpoints unchanged.
	We Participant	can also construct	products of two or more fields in a similar way, for example \begin{equation} where $C_{x \to y}$ is a continuous path from x_1 to x_2.
This shows how	U-field	can in principle be	using Lagrangian

	correlation functions Conventional	calculated	(\ref{02});
	one Participant	has to evaluate	for example, the Wilson line (\ref{05}) in the theory defined by (\ref{02}).
	The classical equations of motion for the Lagrangian (\ref{02}) Instantial	are	\begin{eqnarray}
Taking the covariant divergence on both sides of the first equation of motion, and using the second one,	one Participant	gets	\begin{equation}
Inserting $L_{\mu} = g^{\frac{3-d}{2}} U\partial_{\mu} U^{\dagger}$ in (\ref{07}),	it Conventional	yields	the equations of motion for the usual non-polynomial Lagrangian (\ref{01}).
Note that	the solutions of (\ref{06}) Conventional	will, in general, contain	arbitrary functions of the time.
If we know a solution,	performing on it the transformation: \begin{eqnarray} where $\omega_{\rho \mu \nu}(x)$ is an arbitary completely antisymmetric tensor field, Instantial	will produce	another solution, because $D_{\mu} \delta_{\omega} \theta^{\mu \nu}$ vanishes as a consequence of the Bianchi identity for L_{μ}.
Obviously	d Conventional	must be	larger than one in order that this transformation be well defined, since at least three different indices are needed to have a Bianchi identity.
	This degeneracy in the equations of motion Instantial	is due to	the gauge invariance of the action under the transformations (\ref{08}).
	This gauge-invariance Conventional	makes	the quantization of the model interesting,
and	it Conventional	will allow	us to discuss some properties of the non-linear σ-model from the (unusual) point of view of gauge systems.
	The Hamiltonian formulation of the model Conventional	possesses	a rich structure, since there are second-class constraints (${\cal L}$ is first-order), first-class constraints (for $d > 1$),
and moreover	they	are	reducible for $d > 2$.

	Conventional		
	The structure of the paper Discourse	is	as follows:
In section 2	we Participant	discuss	the Hamiltonian formulation of the $1+1$, $2+1$ and $3+1$ models, following the Dirac algorithm~\cite{dira}.
In section 3	we Participant	construct	the general gauge invariant functionals for the transformations generated by the first-class constraints found in section 2,
and in section 4	we Participant	apply	the Dirac's brackets method to the second-class system formed by the first-class constraints plus some canonical gauge-fixing conditions.
In section 5	we Participant	present	our conclusions.
In Appendix A	we Participant	discuss	a duality relationship between first-class systems, which generalizes a property we discuss for the $2+1$-dimensional model.
\section HAMILTONIAN FORMALISM AND CONSTRAINTS			
\subsection{$1+1$ dimensions}			
From Section 1,	the polynomial Lagrangian in $1+1$ dimensions Conventional	becomes	begin{equation} where θ is a pseudoscalar field.
It is evident that	there Conventional	is	no gauge symmetry in this case.
Thus	there Conventional	will not be	first-class constraints in the Hamiltonian formulation.
However,	there Conventional	are	second-class constraints, because ${\cal L}$ is of first-order in the derivatives.
	This property Conventional	will also appear	in higher dimensions,
so	we Participant	will only discuss	it in some detail for this case.
To start with,	we Participant	rewrite	(\ref{11}) in a more explicit form \begin{equation}
Next	we Participant	define	the canonical momenta, where the primary constraints appear: \begin{eqnarray}
and	the canonical	becomes	\begin{equation}

	Hamiltonian Conventional		where \begin{equation}
	The ‘total’ Hamiltonian Instantial - comment, inverted commas	is constructed	as usual, adding to (\ref{16}) a Lagrange multiplier term for each of the primary constraints (\ref{15}).
Following the Dirac's algorithm	one more constraint Conventional	is obtained:	\begin{equation}
and	the Lagrange multipliers Conventional	become	fully determined.
	The full set of (primary plus secondary) constraints Instantial	is	second-class,
and	its particular form Instantial	allows us	to eliminate the canonical pairs of L_0^a and θ^a, thus effectively eliminating the associated degrees of freedom.
	The Dirac bracket Conventional	becomes	equal to the Poisson bracket for the remaining degrees of freedom.
	The resulting Hamiltonian Instantial	is	\begin{equation} with canonical brackets between the L_1^a's and their momenta π_1^a.
Thus	these two variables Conventional	become	symplectic coordinates on the reduced phase-space, or constraint surface.
\subsection{$2+1$ dimensions}			
	The polynomial Lagrangian in this case Instantial	becomes,	\begin{equation}
	The constraint algorithm Conventional	produces	the $2+1$ analogous of the second-class constraints we showed in Section 1, allowing us to eliminate the 0-component of L_{μ} and all the components of θ_{μ}.
However,	there Conventional	will remain	a set of first-class constraints \begin{equation} with the first-class Hamiltonian \begin{equation}
	They Conventional	satisfy	the algebra \begin{eqnarray}
Now	we Participant	show	in what sense we can relate the massless Yang-Mills theory to the non-linear σ-model in this

			formulation.
	The $SU(N)$ Yang-Mills theory Conventional	is defined	by the Lagrangian \begin{equation} which in the temporal gauge gives rise to the canonical Hamiltonian \begin{equation}
and	*[implicit* subject] Conventional	*[implicit verb]*	the first-class constraints (`Gauss' laws'): \begin{equation} which satisfy the $SU(N)$ algebra \begin{equation}
Note that	(\ref{126}) Conventional	can be rewritten	as \begin{equation} where the G_a's are the ones defined in (\ref{122}).
We then see that	the first-class systems corresponding to the Yang-Mills model and the non-linear σ-model Instantial	can be related	by: 1) Interchanging the constraints: \begin{equation} and 2) Interchanging L_j by $\frac{1}{g} \pi_j$ in the non-derivative terms in the Hamiltonian.
	The generalization of this mapping Instantial - Context Anaphora	is constructed	in Appendix A.
\subsection{$3+1$ dimensions}			
After eliminating the second-class constraints,	one Participant	obtains	a first-class Hamiltonian which looks exactly like the one of the $2+1$-dimensional case: \begin{equation} and the set of first-class constraints \begin{equation}
Although the system seems to be the obvious generalization of the $2+1$-dimensional one,	there InstContext	is	an essential difference:
	The constraints (\ref{132}) Conventional	are	not all independent, but verify the Bianchi identity: \begin{equation}
This implies that	the set of constraints Conventional	is	reducible, containing only two independent functions.
	The counting of degrees of freedom Instantial	then gives	1 for the number of physical dynamical variables ($1 = 3 - 2$).
We mention that	the elimination of the second-class constraints Conventional	applies	in a similar way to the general d-dimensional case,
and that	the Hamiltonian and constraints Conventional	are	the obvious generalizations of (\ref{131}) and (\ref{132}), respectively.

Due to the existence of the Bianchi identity in general,	the number of independent constraints in an arbitrary dimension Instantial	is	just enough to kill $d-1$ out of the d degrees of freedom in H, leading to only one physical variable, as it should be for a model which describes the dynamics of a scalar field.
\section GAUGE INVARIANT FUNCTIONALS			
	Gauge invariant functionals Conventional	are	important from both the classical and quantum mechanical points of view.
Classically,	a complete set of gauge invariant functionals and their equations of motion Instantial	completely determines	the dynamics of the observable, i.e., {\em physical} degrees of freedom.
In Quantum Mechanics,	Dirac's method for first-class constraints Conventional	defines	the `physical' subspace of the complete Hilbert space as the one whose state vectors are annihilated by the first-class constraints, i.e., the gauge-invariant ones.
In the Schroedinger representation,	the physical subspace Conventional	consists of	gauge invariant functionals of the fields.
To construct the gauge invariant functionals,	we Participant	make use of	the concept of gauge invariant projection, defined as follows: Let $I\,=\,I[\pi,L]$ be an arbitrary functional of the phase-space fields.
Then	its gauge-invariant projection ${\cal P}(I)[\pi,L]$ Conventional	is defined	by: \begin{equation} where π^{ω} is the gauge-trasnformed of π by the gauge group element $\omega (x)$ (for example, in $2+1$ dimensions, $\pi_j^{\omega} = \pi_j + \epsilon_{j k} D_k \omega$) and the functional integration is over all the possible configurations for ω.
	The normalization factor ${\cal N}$ Conventional	is	just the volume of the gauge group: ${\cal N} \,=\, \int {\cal D} \omega$.
It is then easy to see that	the gauge invariant projection of an arbitrary functional Conventional	is	indeed gauge invariant: \begin{equation}
and that	${\cal P}$ Conventional	is	a linear projection operator: \begin{eqnarray}

	A functional F Conventional	is	gauge invariant if and only if ${\cal P}(F) = F$.
This can be shown to be equivalent to saying that	F Conventional	belongs to	the image of ${\cal P}$.
	We Participant	then construct	the most general gauge-invariant functional by applying ${\cal P}$ to an arbitrary functional.
In $2+1$ dimensions,	we Participant	further decompose	the momentum as \begin{equation}(where α and β are scalar and pseudoscalar, respectively) to show that \begin{eqnarray} where the last line was obtained by performing the shift $\omega \to \omega - \beta$.
(\ref{25}) shows that	any gauge invariant functional Conventional	is	independent of β;
	the reciprocal Conventional	is	immediate.
	The conclusion Conventional	can be put	as follows:
	The general gauge invariant functional Conventional	depends	arbitrarily on L, an on π only through the combination $D_j \pi_j$.
	This result Conventional	is	generalizable to $3+1$ dimensions.
	F Conventional	is shown	to depend only on $D_j \pi_j$ and L_j, by using the same argument as in the $2+1$ case.
	The decomposition of π_j Conventional	is	now \begin{equation}
and	the β dependence Conventional	is removed	as before by a shift in ω.
	The only difference Instantial	appears	in the actual construction of the projection operator, which appears to be ill-defined at first sight.
	This Instantial - Context Extended reference	is	so because the gauge transformations in $d = 3$: \begin{equation} are invariant under $\omega_j(x) \to \omega_j(x) + D_j \lambda (x)$, for any λ.
	This Instantial Context Extended reference	produces	an infinite factor when one integrates over ω in the definition (\ref{21}) of ${\cal P}(I)$.
Of course,	this factor	is	also present in ${\cal N}$,

	Conventional		
but to explicitly cancel them	on(e) Participant	needs to	`fix the gauge' for the integration over ω.
	A convenient way to do that Instantial	is	by using the Faddeev-Popov trick, which gives the `gauge fixed' projector \begin{eqnarray} where $M_f [\omega]= \frac{\delta}{\delta \lambda}f(\omega^{\lambda}a})$.
We have seen that	the gauge invariant functionals Conventional	depend on	$D_j \pi_j$ and L_j (the result is indeed true in any number of dimensions).
However,	there Instantial Context	is	still a degree of redundancy in this description because one is interested only in gauge invariant functions {\em on-shell}, i.e., on the surface $F_{j k} (L) = 0$.
Thus	we Participant	do not need	the full L_j, but only its restriction to the constraint surface.
As it was shown in ref.~\cite{slav},	it Instantial Context	is	possible to solve that kind of equation using a perturbative approach.
The main result we need to recall is that	that perturbative expansion Conventional	allows one	to express L_j as a function of the scalar $\partial_j L_j$ only.
Then	we Participant	obtain	a more symmetrical description in terms of the gauge-invariant, scalar variables: \begin{equation}
	Their equations of motion Conventional	link	each other: \begin{eqnarray}(where we have included the constraints).
	They Conventional	imply	the second order equations \begin{eqnarray} which show the scalar particle nature of the (only) physical degree of freedom.
	Let us Participant	consider	in more detail the issue of {\em static} solutions in $3+1$ dimensions.
In this situation,	(39) Conventional	reduces to	\begin{eqnarray}
	The first two equations in (\ref{31}) Conventional	are	equivalent to \begin{equation}
	They Conventional	are	exactly the set of equations one gets when considering the Gribov problem~\cite{grib}(for the Yang-Mills theory) in the

			Coulomb gauge, on the orbit of the trivial configuration ($L_j =0$).
It is well known that	there Conventional	are	more solutions than just the trivial one,
in particular,	one Participant	obtains	the `fermionic' configurations of the Skyrme model\footnote{The stabilizing term can be added without changing the canonical structure of the model.}, which verify \begin{equation}
Once a particular solution of (\ref{33}) is obtained,	it Conventional	can be inserted	in the last equation of (\ref{31}) to get an equation for π.
Note that	the momenta Conventional	should then satisfy	\begin{equation} where f_0 is a zero mode of the operator $\partial_j D_j$ (of course, the trivial solution $\pi_j = 0$ is included).
For each Gribov solution L_j,	there Conventional	will be	a non-trivial zero mode for this operator, and then a non-zero solution for the momenta.
	These solutions Conventional	can be compared to	the static solutions of the usual non-polynomial formulation.
To do that	we Participant	must regain	the field L_0, which was eliminated by using the second-class constraints.
	That Instantial Context	is	very simple, since in fact L_0 is equal to a constant times $D_j \pi_j $, and then (\ref{34}) implies \begin{equation}
So	the family of static solutions in the polynomial version Instantial	seems to be	larger than in the usual treatment.
Indeed, as $L_0 = U \partial_0 U^{\dagger}$, a non-zero L_0 implies that	there Conventional	is	a time-dependence for U.
Note, however, that	such configurations Conventional	contribute to	the energy in an amount: \begin{equation} which is proportional to the norm of the zero mode,
and then	the minimum energy Conventional	will correspond to	the trivial configuration $L_0 =0$.
	A simple example of a configuration with $L_0 \neq 0$	is:	\begin{eqnarray} where h is a hermitian (constant) traceless matrix,

	Instantial		and $L_j({\bf x})$ satisfies (\ref{32}).
Thus for (\ref{37}),	$E(L_0)\ Conventional	=\,\frac{1}{2} g^2 tr(h^2) \int d^3 x$,	which is divergent for infinite volume.
\section DIRAC'S BRACKETS METHOD			
As an alternative to the previous approach,	we Participant	apply	here the `Dirac's brackets method' to the treatment of the first-class constraints in the $2+1$ model
	(it Conventional	can however be straightforwardly generalized	to the $d+1$ model).
	It Conventional	consists in	constructing the Dirac's brackets for the set of {\em second-class} constraints containing all the original first-class constraints plus a suitable set of gauge fixing conditions.
	We Participant	choose	the canonical gauge fixing functions: \begin{equation}
	The basic ingredient to calculate the Dirac brackets Instantial	is	the Poisson bracket between χ^a and $G^a (x)$: $\{ \chi^a (x) , G^b (y) \} = (D_1)^{a b} \delta ({\bf x} - {\bf y}) $.
>From this it follows that	the only non-trivial Dirac brackets between canonical variables Instantial	are	\begin{eqnarray}
	The second one Conventional	is	a complicated non-local function.
	It Instantial Context	is	more convenient to take advantage of the results of the previous section to work with L_j and $D_1 \pi_1$.
Then	the Dirac brackets Conventional	become	local \begin{eqnarray}
\section CONCLUSIONS			
	The polynomial formulation (\ref{02}) Conventional	has	an interesting canonical structure.
	Some of its properties Conventional	are:	
	The system Conventional	has	second-class constraints which can be solved explicitly for some coordinates in terms of the

			others.
	This Instantial Context Extended reference	leaves	the canonical pairs associated to the spatial components of a non-Abelian vector field only.
For $d>1$	there Conventional	remain	first-class constraints which form an Abelian algebra.
	They, and the first-class Hamiltonian Conventional	have	essentially the same structure in any number of dimensions.
However, for $d>2$,	the constraints Conventional	are	reducible.
	The number of independent constraints Conventional	is	just enough to leave only one physical degree of freedom.
	These first-class systems Conventional	can be regarded	as `duals' of the Yang-Mills model in the temporal gauge, in the sense that the constraints in one of the systems are non-trivial gauge invariant functions in the other.
	This duality Conventional	can be generalized	to a greater class of first-class systems.
	We Participant	also constructed	the most general gauge invariant functional explicitly.
Note that	the Gauss-law constraints of the dual Yang-Mills system Conventional	appear	here as (non-trivial) gauge invariant objects, verifying the general property discussed in the Appendix.
APPENDIX			
Appendix A: A DUALITY TRANSFORMATION FOR FIRST-CLASS SYSTEMS			
	The kind of `duality' that exists between the massless Yang-Mills theory and the polynomial version of the non-linear σ-model Instantial	is	a particular case of a more general concept, which we define in this Appendix.
	Let us Participant	consider	a constrained dynamical system defined on a phase-space of coordinates $q_j, p_j, \,\,\, j=1 \cdots N$, with first-class Hamiltonian H and a complete set of irreducible first-class constraints $G_a \approx 0 , \,\,\, a=1, \cdots ,N$.
We assume that	the first-class	satisfy	the closed algebra

	constraints Conventional		\begin{equation}
and regarding the Hamiltonian,	we Participant	impose on it the requirement of having the structure \begin{equation}	where the functions $F_a (q,p),\,\,\, a=1, \cdots ,N$ verify the relations \begin{eqnarray} and λ is completely antisymmetric with respect to the last two indices.
This implies that	the Poisson bracket of H and each of the G_a's Instantial	will be	{\em strongly} equal to zero, what is stronger than what we need in a general first-class system.
Indeed,	Equations (\ref{a2}) and (\ref{a3}) Conventional	select	among all the possible first-class systems the class which admit a duality of the kind we are going to define.
	The associated dual first-class system Instantial	is defined	on the same phase-space,
and	its Hamiltonian and constraints (denoted with a dash) Instantial	are defined	by \begin{eqnarray} where F_a and G_a are the ones introduced in (\ref{a1}), (\ref{a2}) and (\ref{a3}).
We then verify that	the new system Conventional	is	also first-class, since \begin{eqnarray} where: \begin{eqnarray}
Thus evidently	this mapping Conventional	leaves	the first-class nature of the system invariant.
Note however, that	the irreducibility of the new constraints Conventional	is	by no means guaranteed.
	That Instantial Context	will depend upon	the particular form of the F_a's.
	An interesting property of the new system Instantial	is	that, because of (\ref{a3}), \begin{equation} which proves that the G_a's constitute a set of M independent gauge invariant functions, which is a very helpful property when one wants to study the classical or quantal dynamics of the system.
Note that	the transformation we defined Instantial	is	not necessarily involutive;
to guarantee that	we Participant	would need	a completely antisymmetric $\lambda_{a b c}$ in Equation (\ref{a3}).
	The Hamiltonian (\ref{a2}) Conventional	resembles	the one of the Yang-Mills system, except for the absence of the term quadratic in the canonical

			momenta.
	We Participant	did not include	this, neither the corresponding one in the dual, to keep the discussion as general as possible.
As they are gauge invariant by themselves,	their presence or not Instantial	do not alter	the essence of the discussion.

APPENDIX I-C

CONTEXTUAL FRAME ANALYSIS CHECK OF PAPER F2

APPENDIX II

STATISTICAL DATA OF THE CORPUS ANALYSIS

APPENDIX II-A

CASE BY CASE DATA FOR THE SUBJECT ANALYSIS

1) Researcher A

Paper	Year		Participant	Discourse	Conventional Phenomena	Instantial Phenomena	Total number of Subjects
A1	1984	0	30	2	121	53	206
A2	1986	2	56	1	153	58	268
A3	1996	12	22	1	58	68	149

Paper	Year		Participant	Discourse	Conventional Phenomena	Instantial Phenomena	Percentages
A1	1984	0	15%	1%	59%	25%	100%
A2	1986	2	21%	-	57%	22%	100%
A3	1996	12	15%	1%	38%	46%	100%

2) Researcher E

Paper	Year		Participant	Discourse	Conventional Phenomena	Instantial Phenomena	Total number of Subjects
E1	1990	0	4	1	30	11	46
E2	1996	6	35	10	148	107	300
E3	1999	9	28	18	111	114	271

Paper	Year		Participant	Discourse	Conventional Phenomena	Instantial Phenomena	Percentages
E1	1990	0	9%	2%	65%	24%	100%
E2	1996	6	12%	3%	50%	35%	100%
E3	1999	9	10%	7%	41%	42%	100%

3) Researcher F

Paper	Year		Participant	Discourse	Conventional Phenomena	Instantial Phenomena	Total number of Subjects
F1	1992	0	42	6	37	19	104
F2	1995	3	32	1	95	42	170
F3	1998	6	46	3	53	46	148

Paper	Year		Participant	Discourse	Conventional Phenomena	Instantial Phenomena	Percentages
F1	1992	0	40%	6%	36%	18%	100%
F2	1995	3	19%	1%	56%	24%	100%
F3	1998	6	31%	2%	36%	31%	100%

4) Researcher G

Paper	Year		Participant	Discourse	Conventional Phenomena	Instantial Phenomena	Total number of Subjects
G1	1982	0	15	6	104	48	173
G2	1994	12	39	7	107	85	238
G3	1997	15	8	3	69	55	135

Paper	Year		Participant	Discourse	Conventional Phenomena	Instantial Phenomena	Percentages
G1	1982	0	9%	3%	61%	27%	100%
G2	1994	12	16%	3%	45%	36%	100%
G3	1997	15	6%	2%	51%	41%	100%

5) Researcher M

Paper	Year		Participant	Discourse	Conventional Phenomena	Instantial Phenomena	Total number of Subjects
M1	1983	0	32	1	37	16	86
M2	1987	4	31	3	32	22	88
M3	1999	16	32	2	102	75	211

Paper	Year		Participant	Discourse	Conventional Phenomena	Instantial Phenomena	Percentages
M1	1983	0	37%	1%	43%	19%	100%
M2	1987	4	36%	3%	36%	25%	100%
M3	1999	16	15%	1%	48%	36%	100%

Paper	Year	Participant	Discourse	Conventional Phenomena	Instantial Phenomena	Total number of Subjects
M3	1999	32	2	102	75	211
M4	1999	48	4	85	38	175
X	unpublished	159	6	149	63	377

Paper	Year	Participant	Discourse	Conventional Phenomena	Instantial Phenomena	Percentages
M3	1999	15%	1%	48%	36%	100%
M4	1999	27%	2%	49%	22%	100%
X	unpublished	42%	2%	40%	16%	100%

6) Researcher O

Paper	Year		Participant	Discourse	Conventional Phenomena	Instantial Phenomena	Total number of Subjects
O1	1991	0	6	2	42	26	76
O2	1994	3	8	3	48	34	93
O3	1998	7	6	6	27	29	68

Paper	Year		Participant	Discourse	Conventional Phenomena	Instantial Phenomena	Percentages
O1	1991	0	8%	3%	55%	34%	100%
O2	1994	3	8%	3%	52%	37%	100%
O3	1998	7	8%	9%	40%	43%	100%

7) Researcher P

Paper	Year		Participant	Discourse	Conventional Phenomena	Instantial Phenomena	Total number of Subjects
P1	1976	0	21	1	37	12	71
P2	1981	5	25	-	75	28	128
P3	1991	15	7	3	110	70	190

Paper	Year		Participant	Discourse	Conventional Phenomena	Instantial Phenomena	Percentages
P1	1976	0	30%	1%	52%	17%	100%
P2	1981	5	20%	-	58%	22%	100%
P3	1991	15	4%	1%	58%	37%	100%

8) Researcher Pro

Paper	Year		Participant	Discourse	Conventional Phenomena	Instantial Phenomena	Total number of Subjects
Pro1	1985	0	14	-	41	18	73
Pro2	1990	5	10	-	41	21	72
Pro3	1999	14	27	14	96	68	205

Paper	Year		Participant	Discourse	Conventional Phenomena	Instantial Phenomena	Percentages
Pro1	1985	0	19%	-	56%	25%	100%
Pro2	1990	5	14%	-	57%	29%	100%
Pro3	1999	14	13%	7%	47%	33%	100%

9) Researcher T

Paper	Year		Participant	Discourse	Conventional Phenomena	Instantial Phenomena	Total number of Subjects
T1	1983	0	57	5	57	23	142
T2	1989	6	37	2	43	40	122
T3	1998	15	42	3	80	38	163
Extra	1998	15	38	7	38	24	107

Paper	Year		Participant	Discourse	Conventional Phenomena	Instantial Phenomena	Percentages
T1	1983	0	40%	4%	40%	16%	100%
T2	1989	6	30%	2%	36%	32%	100%
T3	1998	15	26%	2%	49%	23%	100%
Extra	1998	15	36%	6%	36%	22%	100%

10) Researcher Z

Paper	Year		Participant	Discourse	Conventional Phenomena	Instantial Phenomena	Total number of Subjects
Z1	1988	0	7	-	67	13	87
Z2	1993	5	7	2	109	60	178
Z3	1997	9	4	13	90	56	163

Paper	Year		Participant	Discourse	Conventional Phenomena	Instantial Phenomena	Percentages
Z1	1988	0	8%	-	77%	15%	100%
Z2	1993	5	4%	1%	61%	34%	100%
Z3	1997	9	3%	8%	55%	34%	100%

APPENDIX II-B

TIME ORDERED DATA FOR THE SUBJECT ANALYSIS

Paper	Years	Participant %	Discourse %	Conventional %	Instantial %
A1	0	15	1	59	25
E1	0	9	2	65	24
F1	0	40	6	36	18
G1	0	9	3	61	27
M1	0	37	1	43	19
O1	0	8	3	55	34
P1	0	30	1	52	17
Pro1	0	19	0	56	25
T1	0	40	4	40	16
Z1	0	8	0	77	15
A2	2	21	0	57	22
F2	3	19	1	56	24
O2	3	8	3	52	37
M2	4	36	3	36	25
P2	5	20	0	58	22
Pro2	5	14	0	57	29
Z2	5	4	1	61	34
E2	6	12	3	50	35
F3	6	31	2	36	31
T2	6	30	2	36	32
O3	7	8	9	40	43
E3	9	10	7	41	42
Z3	9	4	8	54	34
A3	12	15	1	38	46
G2	12	16	3	45	36
Pro3	14	13	7	47	33
G3	15	6	2	51	41
P3	15	4	1	58	37
T3	15	26	2	49	23
M3	16	15	1	48	36

APPENDIX II-C

TIME ORDERED INTEGRATED DATA FOR THE SUBJECT ANALYSIS - STATISTICAL FEATURES

Years	Part. Mean	Stan. Dev. Part.	Disc. Mean	Stan. Dev. Disc.	Conv Mean	Stan. Dev. Conv	Inst. Mean	Stan. Dev. Inst.
1 0≤t<2	21,5	14	2,1	2	54,4	12,4	22	6
3 2≤t<4	16	7	1,3	1,52	55	3,6	28	8
5 4≤t<6	18,5	14	1	1,4	52,75	11,2	28	5,2
7 6≤t<8	20,3	12	4	3,4	40,5	6,6	35	5
9 8≤t<10	7	4,2	7,5	0,7	47,5	9,2	38	6
13 12≤t<14	15,5	1	2	1,4	41,5	5	41	7
15 14≤t≤16	12,8	9	2,6	2,5	50,6	4,4	34	6,8

APPENDIX II-D

CASE BY CASE DATA FOR THE CONTEXTUAL FRAME ANALYSIS

1) Researcher A

Paper	Year of publication	Themes	Contextual Frames	(Contextual Frames/Themes) x 100
Paper A1	1984	206	108	52%
Paper A2	1986 (+2)	268	161	60%
Paper A3	1996 (+13)	149	86	58%

	Number of occurrences		Typical Subcategories		Conventional Subcategories			Instantial Subcategories				Expressive Subcategories	
	Year		1	2	3	4	5	6	7	8	9	10	11
A1	1984	0	22	0	14	3	9	7	6	11	16	17	3
A2	1986	2	28	2	18	7	34	2	6	10	29	21	4
A3	1996	12	38	5	8	0	3	0	5	6	4	13	4

	Percentages		Typical Subcategories		Conventional Subcategories			Instantial Subcategories				Expressive Subcategories	
	Year		1	2	3	4	5	6	7	8	9	10	11
A1	1984	0	20%	0	13%	3%	8%	6%	6%	10%	15%	16%	3%
A2	1986	2	17%	1%	11%	5%	21%	1%	4%	6%	18%	13%	3%
A3	1996	12	44%	6%	9%	0	3%	0	6%	7%	5%	15%	5%

2) Researcher E

Paper	Year of publication	Themes	Contextual Frames	(Contextual Frames/Themes) x 100
Paper E1	1990	46	13	28%
Paper E2	1996 (+6)	300	140	47%
Paper E3	1999 (+9)	271	157	58%

	Number of occurrences		Typical Subcategories		Conventional Subcategories			Instantial Subcategories				Expressive Subcategories	
	Year		1	2	3	4	5	6	7	8	9	10	11
E1	1990	0	6	0	1	0	1	0	1	0	1	3	0
E2	1996	6	50	4	16	0	10	2	3	19	9	14	13
E3	1999	9	47	18	22	0	12	2	5	15	7	13	16

	Percentages		Typical Subcategories		Conventional Subcategories			Instantial Subcategories				Expressive Subcategories	
	Year		1	2	3	4	5	6	7	8	9	10	11
E1	1990	0	45%	0	8%	0	8%	0	8%	0	8%	23%	0
E2	1996	6	36%	3%	12%	0	7%	1%	2%	14%	6%	10%	9%
E3	1999	9	30%	12%	14%	0	8%	1%	3%	10%	4%	8%	10%

3) Researcher F

Paper	Year of publication	Themes	Contextual Frames	(Contextual Frames/Themes) x 100
Paper F1	1992	104	67	64%
Paper F2	1995 (+3)	170	96	56%
Paper F3	1998 (+6)	148	87	59%

	Number of occurrences		Typical Subcategories		Conventional Subcategories			Instantial Subcategories				Expressive Subcategories	
	Year		1	2	3	4	5	6	7	8	9	10	11
F1	1992	0	25	0	4	1	4	1	3	1	11	12	5
F2	1995	3	27	5	11	1	6	1	2	6	8	8	21
F3	1998	6	25	1	8	1	2	1	2	5	6	21	15

	Percentages		Typical Subcategories		Conventional Subcategories			Instantial Subcategories				Expressive Subcategories	
	Year		1	2	3	4	5	6	7	8	9	10	11
F1	1992	0	37%	0	6%	1%	6%	1%	5%	1%	17%	18%	8%
F2	1995	3	28%	5%	11%	1%	6%	1%	2%	6%	9%	9%	22%
F3	1998	6	29%	1%	10%	1%	2%	1%	2%	6%	7&	24%	17%

4) Researcher G

Paper	Year of publication	Themes	Contextual Frames	(Contextual Frames/Themes) x 100
Paper G1	1982	173	72	42%
Paper G2	1994 (+12)	238	113	47%
Paper G3	1997 (+15)	135	80	59%

	Number of occurrences		Typical Subcategories		Conventional Subcategories			Instantial Subcategories				Expressive Subcategories	
	Year		1	2	3	4	5	6	7	8	9	10	11
G1	1982	0	31	4	6	0	18	1	1	0	5	3	3
G2	1994	12	54	1	23	0	2	0	5	1	15	8	4
G3	1997	15	34	1	20	1	5	0	2	2	11	1	3

	Percentages		Typical Subcategories		Conventional Subcategories			Instantial Subcategories				Expressive Subcategories	
	Year		1	2	3	4	5	6	7	8	9	10	11
G1	1982	0	43%	7%	8%	0	25%	1%	1%	0	7%	4%	4%
G2	1994	12	48%	1%	20%	0	2%	0	4%	1%	13%	7%	4%
G3	1997	15	42%	1%	25%	1%	6%	0	3%	3%	14%	1%	4%

5) Researcher M

Paper	Year of publication	Themes	Contextual Frames	(Contextual Frames/Themes) x 100
Paper M1	1983	86	65	76%
Paper M2	1987 (+4)	88	59	67%
Paper M3	1999 (+16)	211	126	60%

	Number of occurrences		Typical Subcategories		Conventional Subcategories			Instantial Subcategories				Expressive Subcategories	
	Year		1	2	3	4	5	6	7	8	9	10	11
M1	1983	0	10	1	12	2	6	0	2	3	11	12	6
M2	1987	4	15	2	11	2	8	0	2	9	2	6	2
M3	1999	16	41	9	25	2	10	4	1	6	8	9	11

	Percentages		Typical Subcategories		Conventional Subcategories			Instantial Subcategories				Expressive Subcategories	
	Year		1	2	3	4	5	6	7	8	9	10	11
M1	1983	0	15%	2%	19%	3%	9%	0	3%	5%	17%	18%	9%
M2	1987	4	26%	3%	19%	3%	14%	0	3%	16%	3%	10%	3%
M3	1999	16	32%	7%	20%	2%	8%	3%	1%	5%	6%	7%	9%

6) Researcher O

Paper	Year of publication	Themes	Contextual Frames	(Contextual Frames/Themes) x 100
Paper O1	1991	76	42	54%
Paper O2	1994 (+3)	93	58	62%
Paper O3	1998 (+7)	68	29	43%

	Number of occurrences		Typical Subcategories		Conventional Subcategories			Instantial Subcategories				Expressive Subcategories	
	Year		1	2	3	4	5	6	7	8	9	10	11
O1	1991	0	16	2	4	1	1	1	0	2	5	10	0
O2	1994	3	14	1	5	2	4	1	3	4	1	15	8
O3	1998	7	6	2	5	1	1	0	5	1	3	1	4

	Percentages		Typical Subcategories		Conventional Subcategories			Instantial Subcategories				Expressive Subcategories	
	Year		1	2	3	4	5	6	7	8	9	10	11
O1	1991	0	38%	5%	10%	2%	2%	2%	0	5%	12%	24%	0
O2	1994	3	24%	2%	8%	3%	7%	2%	5%	7%	2%	26%	14%
O3	1998	7	21%	7%	18%	3%	3%	0	18%	3%	10%	3%	14%

7) Researcher P

Paper	Year of publication	Themes	Contextual Frames	(Contextual Frames/Themes) x 100
Paper P1	1976	71	41	58%
Paper P2	1981 (+5)	128	64	50%
Paper P3	1991 (+15)	191	90	47%

	Number of occurrences		Typical Subcategories		Conventional Subcategories			Instantial Subcategories				Expressive Subcategories	
	Year		1	2	3	4	5	6	7	8	9	10	11
P1	1976	0	17	0	0	0	2	0	3	5	5	7	2
P2	1981	5	20	0	5	1	6	1	0	6	5	13	7
P3	1991	15	33	3	10	1	9	1	3	8	8	10	4

	Percentages		Typical Subcategories		Conventional Subcategories			Instantial Subcategories				Expressive Subcategories	
	Year		1	2	3	4	5	6	7	8	9	10	11
P1	1976	0	42%	0	0	0	5%	0	7%	12%	12%	17%	5%
P2	1981	5	31%	0	8%	2%	9%	2%	0	9%	8%	20%	11%
P3	1991	15	37%	3%	11%	1%	10%	1%	3%	9%	9%	11%	5%

8) Researcher Pro

Paper	Year of publication	Themes	Contextual Frames	(Contextual Frames/Themes) x 100
Paper Pro1	1985	73	45	62%
Paper Pro2	1990 (+5)	72	32	44%
Paper Pro3	1999 (+14)	205	121	59%

	Number of occurrences		Typical Subcategories		Conventional Subcategories			Instantial Subcategories				Expressive Subcategories	
	Year		1	2	3	4	5	6	7	8	9	10	11
Pro1	1985	0	11	1	3	0	6	0	3	6	10	3	2
Pro2	1990	5	6	0	6	0	3	3	1	4	1	2	6
Pro3	1999	14	16	8	18	2	14	3	10	10	9	21	10

	Percentages		Typical Subcategories		Conventional Subcategories			Instantial Subcategories				Expressive Subcategories	
	Year		1	2	3	4	5	6	7	8	9	10	11
Pro1	1985	0	25%	2%	7%	0	13%	0	7%	13%	22%	7%	4%
Pro2	1990	5	19%	0	19%	0	9%	9%	3%	13%	3%	6%	19%
Pro3	1999	14	13%	7%	15%	2%	12%	3%	8%	8%	7%	17%	8%

9) Researcher T

Paper	Year of publication	Themes	Contextual Frames	(Contextual Frames/Themes) x 100
Paper T1	1983	142	85	60%
Paper T2	1989 (+6)	122	66	54%
Paper T3	1998 (+15)	163	88	54%

	Number of occurrences		Typical Subcategories		Conventional Subcategories			Instantial Subcategories				Expressive Subcategories	
	Year		1	2	3	4	5	6	7	8	9	10	11
T1	1983	0	12	2	13	0	8	2	1	7	19	14	7
T2	1989	6	16	1	8	2	4	1	1	2	9	17	5
T3	1998	15	24	3	7	3	3	0	0	5	12	17	14

	Percentages		Typical Subcategories		Conventional Subcategories			Instantial Subcategories				Expressive Subcategories	
	Year		1	2	3	4	5	6	7	8	9	10	11
T1	1983	0	14	2%	15%	0	10%	2%	1%	8%	23%	17%	8%
T2	1989	6	24	2%	12%	3%	6%	2%	2%	3%	13%	26%	7%
T3	1998	15	27	3%	8%	3%	3%	0	0	6%	14%	20%	16%

10) Researcher Z

Paper	Year of publication	Themes	Contextual Frames	(Contextual Frames/Themes) x 100
Paper Z1	1988	87	40	46%
Paper Z2	1993 (+5)	178	103	58%
Paper Z3	1997 (+9)	163	101	61%

	Number of occurrences		Typical Subcategories		Conventional Subcategories			Instantial Subcategories				Expressive Subcategories	
	Year		1	2	3	4	5	6	7	8	9	10	11
Z1	1988	0	12	0	4	2	5	0	3	7	1	4	2
Z2	1993	5	19	7	11	3	11	5	4	10	9	14	10
Z3	1997	9	23	3	15	5	9	9	4	5	1	14	13

	Percentages		Typical Subcategories		Conventional Subcategories			Instantial Subcategories				Expressive Subcategories	
	Year		1	2	3	4	5	6	7	8	9	10	11
Z1	1988	0	30	0	10%	5%	13%	0	7%	18%	2%	10%	5%
Z2	1993	5	18	7%	10%	3%	11%	5%	4%	10%	9%	13%	10%
Z3	1997	9	22	3%	15%	5%	9%	9%	4%	5%	1%	14%	13%

APPENDIX II-E

TIME ORDERED DATA FOR THE CONTEXTUAL FRAME ANALYSIS IN FOUR CATEGORIES

Paper	Years	Typical %	Conventional %	Instantial %	Expressive %
A1	0	20	24	37	19
E1	0	45	16	16	23
F1	0	37	13	24	26
G1	0	50	33	9	8
M1	0	17	31	25	27
O1	0	43	14	19	24
P1	0	42	5	31	22
Pro1	0	27	20	42	11
T1	0	16	25	34	25
Z1	0	30	28	27	15
A2	2	18	37	29	16
F2	3	33	18	18	31
O2	3	26	18	16	40
M2	4	29	36	22	13
P2	5	31	19	19	31
Pro2	5	19	28	28	25
Z2	5	25	24	28	23
E2	6	39	19	23	19
F3	6	30	13	16	41
T2	6	26	21	20	33
O3	7	28	24	31	17
E3	9	42	22	18	18
Z3	9	25	29	19	27
A3	12	50	12	18	20
G2	12	49	22	18	11
Pro3	14	20	29	26	25
G3	15	43	32	20	5
P3	15	40	22	22	16
T3	15	30	14	20	36
M3	16	39	30	15	16

APPENDIX II-F

TIME ORDERED DATA FOR THE CONTEXTUAL FRAME ANALYSIS IN ELEVEN SUBCATEGORIES

		Typical		Conventional			Instantial				Expressive	
		Subcat 1 - %	Subcat 2 - %	Subcat 3 - %	Subcat 4 - %	Subcat 5 - %	Subcat 6 - %	Subcat 7 - %	Subcat 8 - %	Subcat 9 - %	Subcat 10 - %	Subcat 11 - %
A1	0	20	0	13	3	8	6	6	10	15	16	3
E1	0	45	0	8	0	8	0	8	0	8	23	0
F1	0	37	0	6	1	6	1	5	1	17	18	8
G1	0	43	7	8	0	25	1	1	0	7	4	4
M1	0	15	2	19	3	9	0	3	5	17	18	9
O1	0	38	5	10	2	2	2	0	5	12	24	0
P1	0	42	0	0	0	5	0	7	12	12	17	5
Pro 1	0	25	2	7	0	13	0	7	13	22	7	4
T1	0	14	2	15	0	10	2	1	8	23	17	8
Z1	0	30	0	10	5	13	0	7	18	2	10	5
A2	2	17	1	11	5	21	1	4	6	18	13	3
F2	3	28	5	11	1	6	1	2	6	9	9	22
O2	3	24	2	8	3	7	2	5	7	2	26	14
M2	4	26	3	19	3	14	0	3	16	3	10	3
P2	5	31	0	8	2	9	2	0	9	8	20	11
Pro 2	5	19	0	19	0	9	9	3	13	3	6	19
Z2	5	18	7	10	3	11	5	4	10	9	13	10
E2	6	36	3	12	0	7	1	2	14	6	10	9
F3	6	29	1	10	1	2	1	2	6	7	24	17
T2	6	24	2	12	3	6	2	2	3	13	26	7
O3	7	21	7	18	3	3	0	18	3	10	3	14
E3	9	30	12	14	0	8	1	3	10	4	8	10
Z3	9	22	3	15	5	9	9	4	5	1	14	13
A3	12	44	6	9	0	3	0	6	7	5	15	5
G2	12	48	1	20	0	2	0	4	1	13	7	4
Pro 3	14	13	7	15	2	12	3	8	8	7	17	8
G3	15	42	1	25	1	6	0	3	3	14	1	4
P3	15	37	3	11	1	10	1	3	9	9	11	5
T3	15	27	3	8	3	3	0	0	6	14	20	16
M3	16	32	7	20	2	8	3	1	5	6	7	9

APPENDIX II-G

TIME ORDERED INTEGRATED DATA FOR THE CONTEXTUAL FRAME ANALYSIS IN FOUR CATEGORIES - STATISTICAL FEATURES

Years	Typic Mean	Typic Stan. Dev.	Conv Mean	Conv Stan. Dev.	Inst Mean	Inst Stan. Dev.	Expr Mean	Expr Stan. Dev.
1 0≤t<2	33	12,4	21	8,9	26,4	10	20	6,6
3 2≤t<4	26	7,5	24	11	21	7	29	12,1
5 4≤t<6	26	5,3	27	7,2	24,3	4,5	23	7,5
7 6≤t<8	31	5,7	19	4,6	22,5	6,4	28	11,5
9 8≤t<10	34	12	26	4,9	18,5	0,7	23	6,4
13 12≤t<14	49,5	0,7	17	7	18	0	16	6,4
15 14≤t≤16	35	9,4	25	7,4	20,6	4	20	11,6

APPENDIX II-H

TIME ORDERED INTEGRATED DATA FOR THE CONTEXTUAL FRAME ANALYSIS IN ELEVEN SUBCATEGORIES - STATISTICAL FEATURES

Typical Class: Subcategory 1 and Subcategory 2

Years	1 Mean	1 Stan. Dev.	2 Mean	2 Stan. Dev.
1 $0 \le t < 2$	31	11.8	2	2.4
3 $2 \le t < 4$	23	5.6	2	1.2
5 $4 \le t < 6$	24	6.1	2.5	3.3
7 $6 \le t < 8$	27.5	6.6	3	2.6
9 $8 \le t < 10$	26	5.7	8	6.4
13 $12 \le t < 14$	46	2.8	3.5	3.5
15 $14 \le t \le 16$	30	11.1	4.2	2.7

Conventional Category: Subcategory 3, Subcategory 4 and Subcategory 5

Years	3 Mean	3 Stan. Dev.	4 Mean	4 Stan. Dev.	5 Mean	5 Stan. Dev.
1 $0 \le t < 2$	10	5.2	1	1.8	10	6.3
3 $2 \le t < 4$	10	1.7	3	2	11	8.4
5 $4 \le t < 6$	14	5.8	2	1.4	11	2.4
7 $6 \le t < 8$	13	3.5	2	1.5	4.5	2.4
9 $8 \le t < 10$	15	0.7	3	3.5	9	0.7
13 $12 \le t < 14$	15	7.8	0	0	3	0.7
15 $14 \le t \le 16$	16	6.8	2	0.8	7.8	3.5

Instantial Category: Subcategory 6, Subcategory 7, Subcategory 8 and Subcategory 9

Years	6 Mean	6 Stan. Dev.	7 Mean	7 Stan. Dev.	8 Mean	8 Stan. Dev.	9 Mean	9 Stan. Dev.
1 0≤t<2	1.2	1.8	5	2.9	7	6.1	14	6.7
3 2≤t<4	1.3	0.6	4	1.5	6	0.6	10	8
5 4≤t<6	4	3.9	3	1.7	12	3.2	6	3.2
7 6≤t<8	1	0.8	6	8	7	5.2	9	3.2
9 8≤t<10	5	5.6	4	0.7	8	3.5	3	2.1
13 12≤t<14	0	0	5	1.4	4	4.2	9	5.7
15 14≤t≤16	1.4	1.5	3	3.1	6.2	2.4	10	3.8

Expressive Category: Subcategory 10 and Subcategory 11

Years	10 Mean	10 Stan. Dev.	11 Mean	11 Stan. Dev.
1 $0 \leq t < 2$	15	6.5	5	2.8
3 $2 \leq t < 4$	16	9	13	9.5
5 $4 \leq t < 6$	12	5.9	11	6.6
7 $6 \leq t < 8$	16	11.1	12	4.6
9 $8 \leq t < 10$	11	4.2	12	2.1
13 $12 \leq t < 14$	11	5.7	5	0.7
15 $14 \leq t \leq 16$	11	7.6	8	4.7