# The epistemic nature of disciplinary discourses: echoing postmodern literary practices

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**ABSTRACT**

This study considers the conflicting demands made upon scientists and engineers when they have to produce rhetorically-sustained texts whose primary concern is to cope not only with the provisional character of scientific truth, but also with the cultural relativism within which the scientific institution –or "order of discourse" (Foucault 1970)– is immersed. By illustrating it with a corpus of thematic articles, this paper attempts to draw attention to those ideological aspects underpinning the rhetoric of scientific and postmodern writing. The analysis of the corpus will provide evidence of how academic literature in science and technology should be interpreted interdisciplinarily in the light of sociorhetorical theories (Berkenkotter and Huckin 1995), critical discourse analysis (Fairclough 1995) and post-structuralist and cultural studies (Lyotard 1984, Solomon 1988, Norris 2000).

**Key words:** rhetoric, social pragmatics, scientific writing, cultural relativism, poststructuralism.

## El carácter epistémico de los discursos disciplinares: un eco de la práctica literaria postmoderna

**RESUMEN**

El propósito de este artículo es el de valorar la dificultad que supone para científicos e ingenieros elaborar un texto académico cuyo marco referencial está sujeto al carácter provisional de la experimentación científica y que, en un contexto más amplio, se hace eco del relativismo cultural en que se ve inmersa la propia institución científica –entendida ésta como "order of discourse" (Foucault 1970). Mediante un corpus de artículos temáticos técnicos este artículo analiza la retórica de la escritura científico-técnica y las convenciones de la literatura postmoderna teniendo en cuenta sus implicaciones ideológicas. El análisis del corpus proporciona evidencia de la manera en la que los discursos especializados deben interpretarse desde perspectivas interdisciplinares como la socioretórica (Berkenkotter y Huckin 1995), el análisis crítico del discurso (Fairclough 1995 y 2003), el postestructuralismo y los estudios culturales (Lyotard 1984, Solomon 1988, Norris 2000).

**Palabras clave:** Retórica, sociopragmática, escritura científica, relativismo cultural, poststructuralismo.



> *Probably the time has indeed come for a complete assessment of the human sciences as a network of converging and diverging perspectives on different dimensions of human reality rather than a collection of disciplines* (J. Verschueren, *Understanding Pragmatics* 1999: 271).

## 1. INTRODUCTION

Classical treatises on scientific writing (Barras 1978, Day 1979, Trimble 1985) put forward three main features in the academic practices of scientists and engineers: objectivity, accuracy and sincerity when reporting their claims. However, rhetorical and systemic-functional studies (Mauranen 1993, Johns 1997, Martin and Veel 1998) highlight the way the social dimension of disciplinary discourses determines the linguistic realisation of texts. The reasons for this particular attention to rhetorical aspects of communication can be found in the cultural and ideological background of contemporary society.

In his article "Changing views: The Chaotic Postmodern and the Old Strategies of Realism in the American Novel" Collado contends that "throughout the twentieth century scientific premises have frequently run along parallel paths to those trodden by philosophers and cultural critics" (1999: 55). Einstein's promulgation of the theory of relativity, the development of quantum mechanics or, in later years, chaos theory, among other scientific advances, have resulted in a deep awareness of the uncertainty of knowledge on the part of cultural theorists (see Solomon 1988). Far from the Newtonian apprehension of external reality according to categorical taxonomies, popular interpretations of contemporary science have progressively led cultural critics in their distrust of a reality that appears to be no longer absolutely observable, since both scientific instruments and the "eyes" of the observer may interfere and thus blur any objective attempt in the transcription of facts.

In part as a result of the development of twentieth-century science, the contemporary cultural landscape is grounded in the relativity and provisionality of the representation of truth. In recent critical theory, different poststructuralist schools reflect upon the uncertain epistemology in which the human being feels trapped since modernist times. Cultural relativism has become one of the stars in current critical debate (see Norris 2000), with many relevant theorists siding for or against the notion of our ultimate uncertain capacity to know the world. In the literary arena "writers have revised their technical strategies so as to fit them within contemporary beliefs about life" (Collado 1999: 55) –beliefs where uncertainty or unpredictability are key terms. Postmodernism itself has been interpreted by many as virtually the condition of distrust of any given value or ideology (Jameson 1984, Lyotard 1984). In a process of cultural feedback, contemporary scientific discourse also experiences a remarkable awareness of the relative condition in the representation of truth (Skelton 1997), an awareness that becomes reflected in the language they use when reporting facts to their expert peers. Put simply, it seems that in scientific research contexts similar "changing views" exist to those that differentiate realist creative literature from (post)modernist texts.

### 1.1. AIMS AND SCOPE OF THE STUDY

The present paper carries out a contrastive analysis of the strategies used by scientists and those favoured by postmodernist writers in their attempt to cope with the provisional character of evidential truth. Bearing in mind that we are comparing texts with completely different functional purposes, the analysis will draw special attention to the social and ideological reasons underpinning the linguistic affinities of both discourses. A corpus of sixteen thematic articles randomly selected from *Computing in Science and Engineering* –a well-known specialised IEEE Computer Society publication– will illustrate the comparison between science and literature practices. The topics that this monographic publication covers are sociologically committed –in the editor's words, topics "that currently seem to be hitting the wall". Only specialised writing rather than popularisations have been included in the corpus to further assess how scientists implicitly assume certain rhetorical rules that are cultural and ideologically bound (Hyland 2000, Flowerdew 2002).

The scientific community has often been described as an elitist social network –or "order of discourse" (see Foucault 1970). The conceptual complexity of specialised writing is addressed to peer colleagues and researchers working in similar areas of enquiry. However, the growing pressure to publish in English in the academic contexts, reasons of prestige and recognition, or simply the need to raise funds force scientists and engineers to use persuasion when presenting their claims –as Mauranen (1993: 31) puts it, "[t]he rhetorical purpose of academic discourse is to convince readers that the author is making a valid claim". This conscious use of rhetoric when reporting specialised conceptualisations resembles the awareness of the social and epistemological landscape depicted in postmodern literary works. By using an interdisciplinary rhetorical-poststructuralist approach, the selected corpus will illustrate several rhetorical practices that lay bare scientists' preoccupation about how to cope with the provisionality of knowledge. The question is: do scientists really stick to the representation of truth and simply present objective facts, or rather, like postmodern writers, do they self-consciously use rhetoric in their writings in an attempt to cope with the contemporary cultural relativism?

## 2. CULTURAL RELATIVISM AND THE SOCIAL LANDSCAPE OF SCIENTIFIC WRITING

Recent studies on the sociology of scientific knowledge further argue that scientists are becoming increasingly aware of the difficult condition of reporting facts whose evidence is ultimately provisional by nature (Battalio 1998). Also, sociorhetorical and critical discourse analyses (Berkenkotter and Huckin 1995, Fairclough 1989 and 1995) describe the scientific register as a social discourse practice subject to issues of culture, ideology and power.

The starting point of the following analysis is Mauranen's study on cultural differences in academic rhetoric, where she suggests some "affinities to postmodernist and deconstructionist work" (1993: 15). Although theoretical and experimental sciences neither question external reality nor the scientific method of observation, they do acknowledge that the very act of translating observable reality into words can be as provisional and subjective as contemporary fiction writers put forward. The "postmodern condition" of scientific writing seems to be sustained upon a paradoxically balanced combination of credibility and persuasion, an interface between objective referentiality and a tentative narration of facts. Echoing literary authors, and in the face of the expertise of peers/readers, scientists use the rhetoric of language to restrict as much as possible the negotiation of meanings and avoid possible counterargumentations, criticisms and confrontations. Correspondingly, the move from realism to postmodern literature resembles the radical shift from a detached reporting of facts towards an overt and socially committed authorial intrusion in research articles. The following table shows those aspects of scientific writing that echo what Stonehill (1988: 30-31) defines as the repertoire of reflexivity in postmodern self-conscious novels.

| **THE POSTMODERN NOVEL** | **THE THEMATIC ARTICLE** |
|---|---|
| • Complex narrative architecture<br>◦ *mise en abyme* stories | • Rhetorical architecture<br>◦ macrostructures and rhetorical moves |
| • Self-conscious narrative flow<br>◦ 'willing suspension of disbelief'<br>◦ narrator's clues to readers | • Decision-making process of information flow<br>◦ lexicogrammatical choices<br>◦ discourse signposting |
| • Self-reflexive techniques<br>◦ self-reflexiveness<br>◦ intertextuality<br>◦ hypotexts | • Self-referential techniques<br>◦ Metatextuality<br>◦ intertextual citations<br>◦ exemplification, visuals, anecdotes,... |
| • Cultural and social criticism<br>◦ problematisation of reality<br>◦ dialogism<br>◦ blurring of boundaries between fiction and reality | • Cultural and social awareness<br>◦ hedging and pragmatic politeness<br>◦ speculation and authorial stance<br>◦ interdisciplinarity (blurring of boundaries between disciplines) |

To carry out a systematic comparison between scientific and postmodern writing, at the beginning of each of the following sections literary techniques will be described briefly as a basis for comparison with the linguistic realisations of the contextual and social aspects entailed in the process of writing science.

### 2.1. DISCIPLINARY WRITING AS A RHETORICAL CONSTRUCT

Postmodern writers tend to create rhetorically complex narrative architectures in an attempt to reject and criticise the conventional linearity of realistic plots. Their main concern underlying this literary practice is to show readers that, as opposed to classical epistemic views, reality is problematic if transcribed through a conventional semiotic code such as language. For scientists, reality can be explained, measured and categorised according to scientific taxonomies; this is what Skelton (1997: 128) calls "evidential truth". However, scientists acknowledge the difficulty of reporting complex conceptualisations while seeking an agreed criterion of readability: to provide the maximum amount of information with the minimum linguistic complexity. Because research papers are highly informational texts, scientists stick to the established IMRaD macrostructure for discourse structuring –Introduction, Materials, Methods and Discussion (Huckin & Olsen, 1983)–, a rhetorical pattern which helps them to organise contents in different sections and subsections for a clearer development of the scientific explanations.

Another way postmodern writers make their narratives more complex is by creating stories within stories. These micro-narratives, called *mise-en abyme* stories, either resemble the main narrative story or lead the readership to establish inferences from them. Quite similarly, introductory sections of scientific articles follow what Swales and Feak (1994) call the CARS (Create-a-Research-Space) model. As *en-abymic* narratives do, this microstructure consists of three main moves that resemble the informational organisation of the whole article. The first move establishes a "research territory" and involves showing that the general research is important, central or interesting. The second one creates "a research niche" by indicating a gap in previous research, raising a question about it or extending previous knowledge in some way. The third move, "occupying the niche", outlines the purposes or states the nature of the present research. To develop this rhetorical structure, scientists follow a problem-solving pattern (Hoey 1983; Weissberg & Buker 1990), that is, an introduction or general background information, the statement of a problem –a need, a lack, a disadvantage, etc.–, its corresponding solution and the evaluation of the results.

Although *Computing in Science and Engineering* does not specify any guidelines for publication, introduction sections adhere to Swales and Feak's suggested pattern. As the corpus illustrates, fourteen articles develop their introductions by moving from a general statement to specific details about procedures, methods and results. Often, retrospective references to previous literature are included in introductions. In addition to giving a background to readers, examples such as "[w]hen looking back at the last 40 years ..." (Frank 2002: 16), "[m]any researchers have undertaken..." (Xu et al. 2002: 50), or "[h]istorically, the military has used..." (Schraml et al. 2002: 16) also show the target audience that writers are well documented about former studies. These textual references to previous research become the source of a problem or gap which is to be solved by the author's current research. Vos's (2002: 66) introduction is shown below to illustrate the rhetorical moves that follow introductory sections in the thematic articles selected (short explanations at the end of each sentence have been added between brackets to summarise what has been stated so far):

> [SITUATION] The outermost layer of the human eye –the cornea, see Figure 1– is of tremendous importance to good vision (*general background statement in the present tense introducing the topic under concern*). By the early 19th century, physicians recognized the cornea's role in the refraction processes (*specific statement in the past tense about previous studies*). In the present day, several types of refractive surgery–such as corneal transplants and laser adjustment of the cornea– have become well established as techniques for improving a patient's sight (*specific statement using present perfect tense to compare current research and previous views*).
>
> [PROBLEM] To support these types of surgery, it is essential to have accurate techniques for measuring corneal shape (*statement that categorically justifies the need*

> *for further research*). However, the systems available for this task have some serious shortcomings (*statement that explicitly indicates a problem or deficiency*).
>
> [SOLUTION-EVALUATION] This article describes how we can use adaptive surface measurement and parallel cluster computing to improve corneal measurement instruments (*statement of the purpose and scope of the paper, suggesting evidence of the need for the improved proposals presented in the paper*).

Like the literary *mise-en-abyme* technique, these encapsulated microtexts mirror the organisational framework of the whole text. In all the articles the introduction is followed by a section describing the antecedents to be solved –Mishra (2002: 43) entitles this section “the problem: comparing genomes”, and Mertens refers to “organization and decision problems” (2002: 33-35), for example. After this section, the solution is detailed in terms of procedures, analyses, applications and results. Finally, the conclusion section details the authors’ assessment and final discussion of the piece of research. Therefore, introductions can be regarded as a rhetorical section targeted at describing the textual and conceptual organisation of the whole article.

### 2.2. SELF-CONSCIOUSNESS AND THE PROCESS OF WRITING OF SCIENTIFIC PAPERS

A novel is self-conscious when it comments on itself to foreground the epistemic condition of ‘imitation’s limitations’ (Stonehill 1988: 2). Fiction writers use narrators who not only tell a story as conventional narrators do, but who also address the intended readers –what Coleridge calls ‘the willing suspension of the disbelief’– to draw attention to the fictional nature of the novel. Using this technique postmodern writers blur the boundaries between the fictional and the real, and encourage readers to discover and interpret the author’s concern with the complexity of transcribing the (social) landscape considering the cultural relativism of the times.

Likewise, scientists consciously guide their readers towards an intended interpretation in order to validate claims which are ultimately provisional and dependent on the observer’s eyes. For instance, because scientific writing involves unilateral communication, scientists write keeping and eye on the audience’s expectations and overtly indicate the communicative purpose of the article –with verbs like *present*, *describe*, *develop*, *formulate*, *review*, or *discuss*– in order to provide readers with an interpretive frame of reference. At other times, scientists use first person singular or plural pronouns thus creating a more favorable interaction between writer and readers. Sentences like “I strongly disagree with...” (Laughlin 2002: 27), “I argue that...” (Mishra 2002: 42), “accordingly we explore ...” (Jarvis & Carter 2002: 33), or “I review fundamental, technology-independent limits” (Frank 2002: 17), among others, entail more involvement on the part of scientists, thus asserting their identity as active researchers.

Scientists use other lexicogrammatical features to guide readers towards a rigorous interpretation of facts. By this means, the transcription of scientific data becomes a conscious process of decision-making. A common linguistic feature in the articles analysed is the marked preference for personification; twelve of them use statements like "this article describes/focuses", "this paper analyses", "the results prove" or "this table illustrates" to avoid mentioning the identity of the researcher and confer more relevance to the finding itself. In addition, the use of reason-result relationships and hypothetical structures helps scientists develop their critical reasoning, thus making the audience infer that the study is worth the effort. To put an example, Jarvis & Carter (2002: 33) foreground their study by stating that "*[t]herefore*, it is important to develop a ceramic coating to act as a thermal barrier that increases the operational lifetime of jet engines and *permits* higher operating temperatures, *thereby* increasing thrust and fuel efficiency" (emphasis added). As stated above, these grammatical features are scientists' conscious rhetorical choices for acknowledging the limited scope of the research –"*because* it would take too much space to survey the technology-specific limits of all present and proposed future computing technologies" (Frank 2002: 17), "our approach differs *because* we don't change the underlying code" (Bahn & Jacobsen 2002: 56), "*[i]f* a complete solution to a terminal ballistic event is required, they must use numerical simulations (Schraml et al 2002: 16).

Another interesting technique that lays bare the scientist's control over the process of writing is the use of discourse markers. Critical and functional approaches to scientific language consider them as "linguistic devices which *explicitly inform the reader* on the ways in which propositions and parts of a text are logically related and linked together to form the global organisation in the text" (Ventola & Mauranen 1991: 463; emphasis added). Johns (1997: 58) stresses the rhetorical role of markers by stating that "writers should provide 'maps' or 'signposts' for the readers throughout the texts, telling the readers where they have been in the text and where they are going". From a pragmatic perspective, linkers explicitly show the relationship between ideas and concepts within a text, and thus facilitate the processing of information by activating the readers' mental schemata –as cognitive approaches postulate (Koenig 1998). As the corpus illustrates, connectors indicate the reader the transition from the problem to the suggested solution. In most of the articles –thirteen out of fifteen– discourse linkers such as *however* (appearing in six articles), *although* (in three articles), *but* (in two articles), *because* (in one article) and *therefore* (in one article) either introduce the problem, lack or gap that must be solved or serve writers to support the solution for the problem.

Accompanying discourse linkage, lexical evaluation (see Winter 1977) provides the audience with explicit textual clues to distinguish between problems and solutions. Lexical references to problems always involve negative connotations (emphasis added): "*...to solve difficult computational problems* continue to emerge [...] several *fundamental questions* arise", (Mishra 2002: 42), "*[u]nfortunately*, peak assignment, of the process's *most time-consuming* steps can *take weeks"*. (Xu et al. 2002: 50), "*[h]owever*, the systems available for this task have some *serious shortcomings*" (Vos 2002: 66), or "*[o]bviously*, forecasting future technological developments is *always* a *difficult and risky* proposition" (Frank 2002: 16). By contrast, the solutions that the scientists suggest are always evaluated in a positive way. As in examples like "[...] which is *the most advanced* and *versatile system known* for programmable construction of nanoscale (Reif 2002: 32) or "*[o]ur* research is part of a *larger effort* to identify *essential* degrees of freedom in molecular simulations" (Best & Hege 2002: 68) (emphasis added), lexical choices subtly draw readers towards accepting the writers' claims as necessary or pertinent.

### 2.3. SELF-REFLEXIVENESS AND THE SCIENTIST'S AWARENESS OF USING LANGUAGE FOR EFFECTIVE COMMUNICATION

Another interesting similarity that can be traced back in the comparative analysis between fiction and scientific writing is the critical notion of self-referentiality or self-reflexiveness. As Stonehill defines it (1988: 17), the attributes of a self-reflexive novel are "a sophisticated awareness of the inherent limitations of both language and thought, a philosophical through-goingness as to its own presuppositions, and an intimate kind of honesty with its reader".

Echoing postmodernist trends, scientists consciously shape their texts keeping in mind their intended readers and purposes. One of the techniques that shows their awareness of the inherent limitations of transcribing evidential truth is what systemic linguists call meta-referentiality,[1] a rhetorical strategy targeted at presenting facts more clearly and convincingly. A text is self-referential when it refers to itself and to the way the conceptual information is depicted. Mauranen (1993: 94) points out that the introductory sections of research articles often contain metareferences –such as "experimental results indicate..." (Reif 2002: 32), "the description here uses..." (Mishra 2002: 42)– that anticipate the scope, methods and results that will later be dealt with in the text. Self-referentiality foregrounds the scientist's concern for the *how* to say things appropriately to facilitate readers' interpretative process. From a rhetorical perspective, metatextual references anticipate the researcher's own account of the events and serve to restrict the negotiation of semantic meaning.

Following Stonehill's repertoire of reflexivity in postmodern novels, the selected corpus also shares another rhetorical feature with literary works, namely, intertextuality. Intertextuality in scientific writing comprises "all influences that shape the text. Some of them very actively giving origin to citations, repetitions, comments or transformations in the final product while others are latent influences or even non-identifiable ones" (Plo 1996: 193). It is a common practice within the academy to integrate references from relevant literature for social reasons. As stated in Purdue University's *Online Writing Laboratory (OWL)*, –one of the most visited websites for students and researchers in science and technology– the use of quotations, paraphrases, examples and summaries in scientific writing provides the author with an accepted status of researcher, draws attention towards a position the writer wishes to agree or disagree with, or helps writers distance from the original by quoting it in order to cue readers that the words are not the writer's own words. For instance, Mishra (2002: 42) uses intertextuality to support

[1] For a further explanation of the concept of self referentiality, see A. Johns's definition of "pre-revealing features" or "metamessages" (1997: 120-122), or Mauranen's "reference items" or "text reflexivity as self-awareness" (1993: Chapter 6).

his hypothesis and argues that "it might be fruitful to examine a quotation by Richard Feynmann, as it reflects on similar questions in the contexts of quantum-mechanical computers". As in the other articles from the corpus, citation of other sources confers more academic rigour to the claims presented.

Special attention should also be given to the rhetorical use of examples if they are compared to literary hypotexts, or texts within the text (see Genette 1982). Exemplification, for instance, further supports the argumentative flow; Boris's article provides solutions to the threat of chemical and biological terrorism and exemplifies it with a reference to "the September 11th terrorist attacks on the World Trade Center" (2002: 22). At other times, examples self-consciously emphasise the provisional nature of scientific claims. Establishing a new parallelism, the following quote from Knoespel (1991: 109) refers to the use of exemplification in contemporary narrative but also becomes valid for academic writing:

> [...] communication functions through an elaborate network of exemplification. Examples helps us make points and enforce stability, but they also open discourse challenging an audience to revise the maps they have used to plot experience. Finally, examples remind us that understanding is temporarily mediated.

Regarding one of the classical canons established for good scientific prose –simplicity of style– exemplification can be regarded as a self-reflexive rhetorical device aimed at persuasion. For instance, at the very beginning of his article, Laughlin (2002: 27) illustrates his main argument through a retrospective account of a personal anecdote:

> Once, as a graduate student, attending an international conference, I made the mistake of admitting during my talk that I could not calculate the optical absorption spectrum of a certain structural defect in an insulator. I meant that I could not calculate accurately, of course, but that did not matter. Before I had time to think or qualify my statement, an ambitious young assistant professor in the back leaped to his feet and yelled, "Maybe *you* can't calculate this spectrum, but I *can*!" His words ring in my ear to this day; one tends not to forget such things. I got through my presentation somehow, retired, and then later went about finding out how this guy had managed to do a computation that I found impossible.

This retrospection in fact contains a morale that allows the author to draw several scientific conclusions, and rhetorically speaking, to provide credibility and prestige to the author's persona as a researcher (emphasis added):

> It turned out to be a wild goose chase. He *could no more do an honest calculation of that spectrum than I could*. He had *simply* redefined "calculation" to mean a **post**diction of a complicated model with lots of parameters fit to the data. *He had also hidden these weaknesses* in a *large, proprietary, poorly documented* computer program, so they could not be discovered without considerable work.

This anecdote provides the reader with a real example to sustain the author's main argument –that "it is understandably difficult for any of us to admit that a calculation is just too hard" (op. cit., p. 27). A few pages later, Laughlin overtly reflects upon the relativity of truth when using simulations that exceed the limits of validity as far as scientific knowledge is concerned. Surprising for a piece of scientific writing, it is not simply objective facts what the article reports, as the scientist questions the provisional nature of the process of observation that these facts involve. Echoing those philosophical undertones of postmodern fiction, this author uses an intertextual reference –precisely that of a famous novelist– to support his reasoning when dealing with the difficulty of approaching the concept of 'truth' from the parameters of computer-mediated simulations:

> Mark Twain captured the problem when he said that truth is always stranger than fiction because fiction is forced to stick to possibilities, while truth is not. Real science always begins with careful observations of nature and thoughtful consideration of facts "that ought not to be true" but nonetheless are. Studying only a simulated world based on what one *thinks* is true rather than what actually is true automatically precludes rethinking the facts, and therefore automatically precludes making a fundamental discovery. (op. cit.: 29)

The intertextual citation helps the writer to reach similar philosophical conclusions to those of postmodernists by weighing the misuse of scientific discoveries vs. the ethical integrity of physical science, and by ultimately showing respect for science and its institutional matrix: "[a]s caretakers of tradition [...], we are obligated to remind our fellow citizens and the younger generations that real science deals with truth and is as different from falsehood as night is from day" (op. cit.: 30).

To substantiate scientists' claims is also the purpose of another recurrent element of academic writing: the use of visuals. Echoing what Genette (1982) calls 'hypotexts,' or stories within the main narrative story, illustrations become simplified microtexts of the most relevant information of the whole article and, as such, emphasise the conceptualisations of the primary text. Line graphs, flow charts, tables, pies, diagrams or drawings can be regarded as simplified pre-texts since they contain information which has been gathered and prepared in advance by the scientist before writing the final draft of the article. The main function of visuals is to assess –"mirror"– what the text itself explains, and foreground the propositional contents of the article by providing further details, synthesising or clarifying the information, emphasising important results and, ultimately, validating the theory or experiment under consideration. For instance, the following extract from Jarvis and Carter (2002: 33) describes the authors' proposal by specifying the functional and physical features of their research and synthesising these ideas in a visual, most probably, with the purpose of facilitating the readers' information processing. Because visuals "make an immediate impact, serve the double function of depiction and corroboration" (Barras 1978: 109) technical specifications are systematically provided with greater detail and accuracy:

> The TCB of choice, a thin yttria-stabilized-zirconia (YSZ) coating, *reduces* the temperature to which the underlying superalloy is exposed by hundreds of degrees Celsius. A TCB *consists of* three primary layers that cover the macroscopic engine superalloy: the YSZ thermal protective layer, the thermally grown oxide (TGO) *formed through*

> bond coat oxidation, and the metal alloy bond coat *composed of* Ni(Co)CrA1Y. *Figure 1 shows a schematic representation* of a TBC's cross section. (emphasis added)

Through these self-conscious techniques, writers help their readers in their interpretive process and prove to be aware of the importance of using language effectively for optimal relevance in communication (Wilson and Sperber 1998).

### 2.4. SCIENCE AND THE PROBLEMATISATION OF EVIDENTIAL TRUTH

One of the most recurrent *topoi* among postmodern authors is to explore the importance of language and meaning making on social life. Writers' main concern is to lay bare the problematisation of using a restricted semiotic code such as language to describe a complex social landscape ruled by cultural relativism and uncertainty. Interestingly, the conclusion sections of the articles from the corpus deal with the representation of truth and the validity of the scientific method. Whereas materials/methods and results sections are purely descriptive parts based on objective data –materials, methods and results–, conclusions include an evaluative commentary resulting from the application of the scientific method, and are "more connected to the real world or more concerned with applications and implications and, if possible, some combination of these" (Swales & Feak 1994: 196).

Since scientists need to highlight their theses and arguments, conclusions often contain a fair amount of speculation, an aspect that also pertains to postmodernism. As Skelton (1997: 132) claims, "the speculation creates a new truth, a tentative and provisional truth of interpretations and possibilities, and it is a major function of the Discussion section to sketch out those possibilities". Bearing in mind the problematisation of evidential truth, conclusion sections tend to follow three rhetorical moves: an explanation of those important points that validate the experiment or finding (move 1); a reference to those facts or aspects that limit the study (move 2), and a reference to useful areas for further research (move 3). By way of illustration, Peterkin and Luginsland (2002: 42) employ a rhetorically effective comparison to give evidence to their claims and also to show respect to the scientific authority: "This is *perhaps not as great* a conceptual paradigm shift as that which took place during the Copernican revolution, overthrowing the Ptolemaic view of the universe, but it is *no less revolutionary in the practice and culture of science*" (emphasis added). Thus, the use of rhetorical conventions once again becomes a subtle way to validate the research once absolute truth has been questioned.

It is also interesting to point out how closely scientific writing resembles Bakhtin's (1986) concept of dialogism. For Bakhtin, utterances are not only connected to diction and syntax but are also social and contextual. Opposing the monologic style of realistic novels postmodern narratives develop a dialogic web of multiple narrative accounts for the purpose of foregrounding the epistemic difficulty of transcribing the physical world into words. Quite similarly, scientists also use two overlapping voices when writing conclusions. First, an objective 'narrator' outlines and summarises the most relevant findings from the research, but then this objective voice is overlapped by more committed and evaluative commentaries that reveal the author's intrusion in the text for social and institutional reasons. In fact, these two rhetorical voices represent two different layers of meaning potential and entail scientists' deep concern for the social context within which scientific writing is produced. The more scientists claim the significance of their findings, the more chances they have to be accepted by and recognised as members of the scientific community. Put simply, scientific language relies on the premises of social interaction and writing practices are ultimately dependant on a broader social order.

This text-discourse-society relationship explains the rules of pragmatic politeness in disciplinary practices (Brown and Levinson 1987, Myers 1989). Alcaraz (2000) remarks that although it is the quality of science that determines whether an article is accepted for publication, scientists are becoming increasingly concerned with accomodating their texts to the social conventions established by the community. The process of scientific writing therefore entails not only an accurate transcription of facts, but also a rhetorical exercise targeted at convincing the audience; as Hyland (2000: 74) puts it, to "explicitly emphasise the value of the paper, either to the disciple or to the wider community".

As the corpus exemplifies, together with the purely referential transcription of scientific observations all along the central sections of the articles, scientists problematise their objective –"realist"– explanations by laying bare the provisionality of scientific truth in the conclusions sections. This fact explains the scientists' acceptance of limitations and the avoidance of any categorical statement in the articles analysed. Reif (2002: 40) starts the conclusion section by stating that "[t]here remain many open research issues that we are currently pursuing. [...]. However, there may be critical barriers that we must overcome", and closes it –in a rather philosophical undertone– by putting forward the unstoppable advance of science: "[w]e expect that in the next decade, *researchers will succeed* in attaching various classes of molecules to DNA arrays, and a significant portion of the application work I discussed above *will come to pass*" (p. 41).

At times, the limitations of scientific research are justified by politely requesting financial support to continue their research: "Again, *unless support* for this activity is forthcoming, it is *unfortunately unlikely that* the small team currently working on this project *would be able to pursue* this work" (Stainforth et al. 2002: 89, emphasis added). Alternatively, some writers prefer to over-use hedging devices (Salager-Meyer 1994) like modal verbs, adverbs and expressions of probability to mitigate categorical claims and arguments. Skelton (1997: 125) argues that hedges "are associated above all with the removal of a personal stake in the truth value of a proposition" and explains that

> ... authors use speculations to make tentative suggestions which would explain their findings. They are typically realized through the hedging system or through comments such as support or suggest [...]. If they are not to be taken as comments of certainty, they may be interpreted as representing possibilities (on the whole, rather than explicit suggestions) for future research. (p. 133).

At other times, hedges like *might*, *may*, *probably*, *perhaps*, *unlikely,* etc. become useful rhetorical tools which allow scientists not to be taxonomic, but rather tentative and cautious in the presentation of their claims. Hedges help maintain a distance and entail the idea that the scope of the research is temporary and its validity uncertain. This is the case of Lewin's (2002: 8) last paragraph of the conclusion, quoted below. In this extract interdisciplinary links between science and literature are explicitly referred to:

> Thus, *it appears that* macromolecular computing is blurring the lines between computing, materials science, and robotics. *At least* at the molecular scale, *it might be possible* to use the same class of molecules to build, program, and operate molecular-scale devices whose applications *have only been foreshadowed by science fiction*. (emphasis added)

For social and pragmatic reasons, scientists acknowledge the need of future research and the need for interdisciplinary studies among disciplines. Through conscious lexicogrammatical choices they subtly pave the way for further research: "it is *apparent* that *rigorous* mathematical study of simulation models is *worth the effort*. Partitioning the parameter space *is a good starting point*, and *no doubt* other *useful* tools exist and *can* be developed" (emphasis added); "[e]fforts such as ours can only succeed if they are closely tied to research in experimental biology", state Alur et al. (2002: 29); similarly, Reif (2002: 41) openly remarks that "[d]oing so will require a collaborative interdisciplinary research approach that spans many disciplines".

Even more unusual according to the premise of objective reporting are those subjective appreciations on the part of the scientists that lay bare the persuasive force of the article. In the following examples, first-person pronoun references encourage interdisciplinary research among disciplines in an attempt to show a deep concern for science and its institutional order. Once again, pragmatic politeness becomes a key interactional feature in contemporary science writing practices (emphasis added):

> *Hopefully, some of the general considerations we've presented will help others* constructing similar interfaces for their codes. In several fields, integrating different methods and codes is becoming a key issue. In materials science, many important problems naturally involve phenomena ranging from the nanometer scale to micrometers or longer. [...]. In molecular biochemistry, this integration of different methods and codes is also an important topic. (Bahn and Jacobsen 2002: 65-66).
>
> *Reading up to this point hopefully has convinced* you that there are some *interesting links* between physics and the theory of computational complexity. In fact, mathematicians, computer scientists, and physicists have just started *interdisciplinary work* in this field. [...] If this really happens, computational complexity and physics *will no longer be considered separate fields*. (Mertens 2002: 46).
>
> *I hope that this article inspires researchers in many fields* to devote increased attention to finding ways to meet the incredible challenges facing the future of computing as it approaches the many limits found at the atomic scale. (Frank 2002: 25).

To sum up, conclusion sections illustrate scientists' concern for intellectual authority –or "order of discourse"– rather than individual authority. Rhetorical devices such as those analysed above foreground the respect of the writer for the scientific community, regarded both as an elitist membership and as the "keeper" or "guardian" of scientific reasoning itself. Perhaps becoming subjective and sincere should be understood as a gesture of modesty towards the institution when requesting acceptance of the writer's claims by the scientific community. Perhaps, interdisciplinarity could be the key –as scientists recurrently insist at a textual level– to overcoming the provisional character of scientific observation and, like postmodern literary trends, implicitly accept the impossibility of reaching absolute truth. In any case, social pragmatics in scientific writing becomes a suitable interface between discourse analysis and the sociology of scientific knowledge.

## 3. DISCUSSION AND IMPLICATIONS

Echoing a postmodernist understanding of life as something uncertain and relativistic, it seems that scientific literature can also, in a sense, be regarded as a "postmodern" construct, as an artifact that shows deep concern for the new sign of the times: the realisation that "*what* is the world has been replaced by *how* is the world interpreted and reported" by different speakers and writers (Collado 1999: 67).

The literary critic Linda Hutcheon (1989) argued that the main pillar of postmodernist fiction is the problematisation of referential representation. Similarly, it seems that nowadays the task of scientists- and engineers-writers is not simply to explore and observe the world in the most accurate way, but also to acknowledge that the process of communicating and interpreting these scientific observations should be approached in probabilistic and tentative terms. Like contemporary fiction, disciplinary writing proves to be a process of conscious decision-making involving a strategic use of both linguistic and rhetorical devices.

As exemplified and referenced with the corpus of thematic articles, the rethorical complexity of the academic register lies precisely in the epistemic nature of science and in its institutionalised discourse practices. It seems we are facing once again the postmodern relativist dilemma that there is no way to escape language, since even an objective semiotic code like that of scientific prose is open to textual and interpretive demands that result from powerful social implications. Both sociopragmatic and ideological orders of discourse affect specialised registers like that of science and technology, thereby calling for a "postmodern" relativistic redefinition of the classical premises of scientific writing. To borrow Verschueren's words (1987: 5):

> One could say that, in general, the *pragmatic perspective* centers around the *adaptability of language*, the fundamental property of language which enables us to engage in the activity of talking which consists in the constant making of choices, at every level of linguistic structure in harmony with the requirements of people, their beliefs, desires and intentions, and the real-world circumstances in which they interact.

In this sense, disciplinary writing reifies a "postmodern" paradoxical interface between the interpersonal and the ideological semiotics underlying the transcription of scientific truth. As Halliday and Martin conclude, research literature in these fields should cover two complementary perspectives, "the perspective of language (science and text) and the perspective of social context (science and institution)" (1993: 25). Further research on sociorhetorical aspects of the scientific register together with fruitful insights into the sociology of scientific knowledge will offer a more integrative view of academic discourse in an attempt to bridge the gap between the scientific, philosophical and cultural domains.

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