HEDGING IN
SCIENTIFIC
RESEARCH ARTICLES

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Preface

There is a widely held belief that scientific writing is purely objective, impersonal and informational, designed to disguise the author and deal directly with facts and the search for an independent truth. But effective academic writing is like any other kind of discourse in that it is interactive, it involves writers trying to influence their readers by persuading them of the correctness of their claims. This means that research papers do not only carry the writer's point of view, but that arguments have to be expressed in ways that are acceptable, meaningful and plausible to colleagues. A growing literature in both sociology and applied linguistics has therefore begun to turn its attention to the social contexts of writing and the ways that knowledge is a negotiated accomplishment. Persuading readers to accept a particular observation as a fact involves relying on disciplinary assumptions about how best to represent experiments, contextualise results and present oneself. One important means of achieving this is the use of hedges to present claims with caution, precision and humility.

Hedging is central to academic writing as it expresses possibility rather than certainty and collegiality rather than presumption. Scientific claims are rarely made without interpretive statements and these involve both assessments of probability and judgements concerning the impact of linguistic choices on readers. In other words, academic writing involves cognition and cognition almost invariably involves discretion. Hedging is one crucial means by which writers manage this pragmatic dimension of discourse and in this study I attempt to throw some light on their use in published scientific papers. In particular, I examine why scientists hedge and set out to describe the ways they do this, identifying the forms they use, how they are distributed and their specific functions in this genre.

There are four central arguments in this book. The first is that hedges are employed to achieve a single primary objective: to overcome the inherent negatability of statements and gain the reader's acceptance of a knowledge claim. Second, I suggest that in achieving this objective hedges can emphasise an orientation to either the proposition or the reader, and that the former may focus primarily on achieving propositional accuracy or minimising writer accountability. Third, I show that in actual use the epistemic and affective functions of hedges are often conveyed simultaneously and that this indeterminacy prevents the formation of discrete descriptive categories. My fourth main argument is that hedging in scientific research writing is the product of informational, rhetorical and personal choices and cannot be fully understood in isolation from its social and institutional contexts. The pragmatic framework therefore seeks to accommodate both a complex interpretive environment and a perspective which accepts imprecision as an important characteristic of language use.

Given this broad context, the book ranges over a number of areas and critically examines their contributions to the field before presenting the descriptive and analytical model. Chapter 1 provides some background and an overview of the topic. In chapters 2 and 3 I seek to provide a rationale for the use of hedging by examining a variety of perspectives in the literature. My focus in chapter 2 is the broad socio-linguistic institutional contexts within which hedging occurs and has meaning. Here I explore the practices, beliefs, assumptions and goals which constitute biologists culturally and historically organised social worlds, providing a characterisation of scientific discourse from sociological, speech act and applied linguistic approaches. In chapter 3 I review the work on hedging more specifically.

In chapter 4 I discuss some central assumptions of the study and outline the research design and methodology. Chapters 5, 6 and 7 are the core of the book. Chapter 5 describes the surface features of hedging in the corpora and Chapter 6 presents a framework to account for their pragmatic functions in this genre. In chapter 7 I apply this framework to a number of extended text fragments and a complete research article. Having established the significance of hedging in scientific writing, I investigate its importance to second language students in chapter 8, exploring the coverage it receives in pedagogic methods and materials, and outlining some teaching approaches. In the concluding chapter I consider some implications of the study, and suggest future directions for research.

Acknowledgements

1 On Hedging and Hedges

Since ... perception only gives information of this external world or of "physical reality" indirectly, we can only grasp the latter by speculative means. It follows from this that our notions of physical reality can never be final. We must always be ready to change these notions ...

(Albert Einstein)

What is hedging?

The notion of hedging has been in the linguistic vocabulary since the term was introduced by Lakoff (1972) to describe "words whose job it is to make things more or less fuzzy". It has subsequently been applied to the linguistic devices used to qualify a speaker's confidence in the truth of a proposition, the kind of caveats like *I think, perhaps, might* and *maybe* which we routinely add to our statements to avoid commitment to categorical assertions. Hedges therefore express tentativeness and possibility in communication, and their appropriate use in scientific discourse is critical.

Definitions are surprisingly rare in the literature. Zuck and Zuck (1986) refer to hedging as the process whereby the author reduces the strength of a statement, while for Markkanen and Schröder (1989) it is any manipulative, non-direct sentence strategy of saying less than one means. My sense of the term is closer to the first of these definitions, as I wish to include in it statements that express exactly what the author means, saying no more than is warranted by available evidence. Hedging is not a strategy to obfuscate or confuse, any more than it is simply a convention of academic style.

In this study then, "hedging" refers to any linguistic means used to indicate either a) a lack of complete commitment to the truth value of an accompanying proposition, or b) a desire not to express that commitment categorically.

In essence, the purpose of this book is to elucidate this definition, locate it within linguistic theory and demonstrate its relevance to scientific discourse. The value of such an enterprise has been emphasised by Holmes (1984: 364) who states that:

> Identifying and describing the linguistic devices which may be used to modify illocutionary force constitutes a rich research field for those interested in pragmatics. And for the sociolinguist there is the challenge of investigating the differential use made of such pragmatic resources by different categories of speakers, to different addressees, in different social contexts.

The writer or speaker's judgements about statements and their possible effects on interlocutors is the essence of hedging, and this clearly places epistemic modality at the centre of our interest. Coates (1987: 112) describes epistemic modality as concerned with "the speaker's assumptions, or assessment of possibilities, and, in most cases, it indicates the speaker's confidence, or lack of confidence in the truth of the proposition expressed." Lyons' (1977: 797) definition of epistemic modality is well known: "any utterance in which the speaker explicitly qualifies his commitment to the truth of the proposition expressed by the sentence he utters ... is an epistemically modal, or modalised sentence."

Most commentators therefore refer to the epistemic system as realising a continuum of "commitment" on the part of the writer to the truth value of his or her statements, ranging from uncertain possibility to confident necessity. Its importance lies in the fact that such tentativeness avoids personal accountability for statements, reducing the author's "degree of liability" (Huebler, 1983:18), while expressing caution and facilitating open discussion. Beyond this is the declarative sentence. Epistemic comment is seen by many writers as being at the heart of language use and a principal means by which speakers can use language flexibly to adopt positions, express a point of view and display allegiances (eg Lyons, 1977; Stubbs, 1986). It is one of the principal resources we have for conveying choice and meaning (Skelton, 1997) and without it, language would be purely propositional and rigid.

Writers cannot avoid encoding their point of view towards whatever they say, commenting on and committing or distancing themselves from their propositions. As Stubbs (1986: 4) observes: the expression of commitment and

detachment, or of modality in all its senses, can be seen as a central organising principle in language. Where this involves the writer withholding full commitment to statements, I have called it hedging.

What is a hedge?

Halliday (1994:356) refers to modality as "the area of meaning that lies between yes and no", taking in "either yes or no" and "both yes and no". Because judgements about truth and falsehood, certainty and doubt, probability and possibility play such an important role in our lives, they allow a wide range of lexical, grammatical and strategic realisations. There are an enormous number of ways writers can signal tentative assessments of referential information, and a variety of reasons for doing so, therefore it is worth briefly clarifying what 'counts' as a hedge in the sense used in this book. It is also worth making the obvious point that hedges are represented by surface phenomena of texts and we require their presence to detect the function. The most apparently categorical statement may draw on participant understandings to convey attitudes about its content or readers, but we are able to say little about this without linguistic confirmation.

As noted above, hedging is one part of epistemic modality; it indicates an unwillingness to make an explicit and complete commitment to the truth of propositions. In everyday conversation hedges are commonly expressed through auxiliary verbs and by epistemic adjectives, adverbs and lexical verbs. Common conversational forms include words like *Perhaps, I guess, may be, quite* and *sort of,* while prosody, tag questions, verbal fillers and hesitation markers also function as hedges when they are used to attenuate the strength of an utterance (Coates & Cameron, 1988; Holmes, 1995). Academic research writing also includes diverse expressions of hedging which make use of the full range of epistemic lexical resources[1]:

> (1) ... it seems that this group plays a critical role in orienting the carboxyl function.   (E1:294)

> (2) It might be speculated that the lack of crDNA methylation in cv Platenese could result in enhanced amounts of mRNA in choroplasts.
>   (F3:17)

(3) ..a model implying almost complete lateral heterogeneity in the thylakoid membrane could be suggested, nearly all Photosystem II being situated in the appressed granal domain.   (A5:172)

Hedges can thus be employed either singly or in combination. But in addition to lexical items, scientific statements can be weakened using a variety of strategies which limit the confidence invested in the claims made for the research. These can include drawing attention to the limitations of results or the experimental conditions in which they were obtained, and this is often achieved by commenting on difficulties encountered, shortcomings of findings or the possibility of alternative interpretations:

(4) Crystallographic investigation of membrane proteins is difficult because of the difficulty of obtaining suitable diffraction quality crystals.
                                                                (C3:281)
(5) ...implies that phytochrome A is also not necessary for normal photomorphogenesis, at least under these irradiation conditions.   (D4:46)

(6) ...could be explained by the fact that in these fractions the majority of PMB and PBF results from functional infected cells that do not contain the 21-kD protein, and/or by the fact that senescent vesicules are more fragile than .....   (D2:266)

Thus hedging is not limited to lexical expression and the data reveals questions, IF-clauses and contrastive markers that can qualify certainty and indicate a measure of the writer's doubt by making the truth of a proposition relative to the current state of (limited) knowledge:

(7) How is it, then, that this gene from a species that never forms nodules has the capacity to be expressed at elevated levels in nodules? The answer presumably has implications for the evolutionary origin of nodulation ability and nodule-specific gene expression ..   (D1:637)

(8) If correct, this prediction might explain why previous exhaustive screens have ..   (D4:40)

(9) Although a causal relationship between the latter processes remains to be verified, the correlation may not reflect mere coincidence.   (B1:192)

Writers have also noted that use of the passive voice and tense can serve to hedge statements by distancing the writer from his or her assertions. However, the difficulty of determining the precise motivation and effect of these syntactic strategies with any assurance places them outside the scope of this study.

It should also be noted that many statements express opinions, viewpoints, attitudes and feelings, but not all are hedges. Commentary on propositional content can also signal the writer's personal feelings about a topic (Surprisingly..., it is terrifying to think that...) or intensify one's conviction of its truth (It is obviously the case that ..., the results clearly show..). However, the term hedging does not include all devices used to express attitudes or to comment metadiscoursally on the text, nor, of course, does it comprise epistemic devices which convey the writer's conviction in the truth of a statement. Sometimes it may be difficult distinguishing truth judgements from value judgements (Skelton, 1997:125), particularly in a context as rhetorically charged as scientific argument where the precise appeal to the audience is not always clear. However, my definition does not require this and allows any statement of reservation to be examined for its hedging value.

Similarly, while hedges have been seen as one device often used to mitigate threats to the 'face' or self-image of interlocutors (Brown & Levinson, 1987; Myers, 1989), not all expressions of politeness act to qualify writer commitment. One function of hedges is to contribute to a relationship by alerting readers to the writer's perspective towards both propositional information and to the readers themselves. "Facework" however is accomplished by a range of strategies which also include markers of obligation, politeness and reluctance, as well as swear words and title forms (Turnbull & Saxton, 1997; Wood & Kroger, 1994). A range of interactional and evaluative features are subsumed under Halliday's (1994) interpersonal macro function of language, which is contrasted with the textual, or enabling, and the ideational, or informational, functions. Thus while hedges constitute one aspect of the interpersonal domain of language, they are distinct from other elements of it.

In sum, in this study hedges are the means by which writers can present a proposition as an opinion rather than a fact: items are only hedges in their epistemic sense, and only then when they mark uncertainty.

Why study scientific hedging?

Despite a widely held belief that professional scientific writing is a series of impersonal statements of fact which add up to the truth, hedges are abundant in science and play a critical role in academic writing. Hedges are important to scientists because, as the quotation from Einstein at the head of this chapter emphasises, even the most assured scientific propositions have an inherently limited period of acceptance. Categorical assertions of truth in these circumstances are decidedly hazardous. Science writing involves weighing evidence, drawing conclusions from data, and stating circumstances which allow these conclusions to be accepted; it assesses the claims it makes. Nash states this position succinctly:

> The writer .... currently evaluates and criticises the information and the propositions he or she tries to set down as fully, accurately. and objectively as possible. For centuries this dialectical processing of objective fact and subjective evaluation has been the goal of academic writing and of the training that leads to academic writing.   (Nash, 1990: 10).

Academic discourse invariably involves interpretative statements because academics are crucially concerned with varieties of cognition, and cognition is inevitably hedged, with writers offering an assessment of the referential information they provide. Rather than being factual and impersonal, effective scientific writing actually depends on means of augmenting propositional information in order to alert readers to the writer's opinion.

A good reason for studying scientific hedging is therefore to reveal an essential element of academic argument. Hedges are a crucial means of presenting new claims for ratification and are among the primary features which shape the research article (RA) as the principal vehicle for new knowledge. Hedging enables writers to express a perspective on their statements, to present unproven claims with caution and to enter into a dialogue with their audiences. It is therefore a substantial means by which scientists confirm their membership of the scientific community: "hedging is the mark of a professional scientist, one who acknowledges the caution with which he or she does science and writes on science" (Crismore & Farnsworth, 1990: 135). Its study therefore has important implications for a number of areas.

Most importantly, a better understanding of how hedges are used in scientific research articles can contribute to the growing literature on the rhetoric of science, providing insights into how science establishes its claims to knowledge, and how scientists carry out their work. The research article is a genre clearly distinguished by its role in reporting new experiments intended to add to the existing knowledge of the discipline (cf. Swales, 1990). It is the major vehicle for knowledge in academic cultures and an artefact central to the legitimation of a discipline and the reputation of its practitioners. Its importance has been confirmed in recent years by studies which have critically debated the epistemological foundation of scientific knowledge and questioned the role of the RA as simply a transmitter of facts. These studies have established that the RA is a significant rhetorical artefact, which acts to both conceal the contingency of knowledge and persuade readers to accept claims (eg Latour & Woolgar, 1979; Gilbert & Mulkay, 1984; Bazerman, 1988).

Essentially, scientific knowledge is seen as less a coherent body of objective truth about the world than a set of justifiable beliefs reached by the scientific discourse community and constructed through interactions among individuals. In this view the accreditation of knowledge is a social process and research is perceived as a quest for collective agreement rather than a search for truth (eg Kuhn, 1970; Ziman, 1984; Longino, 1990). Consequently, scientific argument is part of a rhetoric employed to convince readers of the validity of claims. This search for consensus provides the motivation for the expression of doubt and tentativeness in science for such interpretations can help secure readers' acceptance. Statements require audience ratification and this requires the reader's active role in how the writer constructs claims. In other words, hedges are an important rhetorical device in academic writing as they signal the writer's anticipation of the negatability of his/her propositions.

Information about hedging can also contribute to our understanding of the practice of evidential reasoning and the structure of argumentation as discussed by Toulmin (1958), Longino (1990) and others. Toulmin's widely known system defines the elements of reasoning to be the grounds (established data), the warrant (facts supporting the hypothesis), the qualifier (degree of uncertainty concerning the connection between grounds and claim), the claim (proposed conclusion) and the rebuttal (elements of doubt concerning the claim). Hedges clearly contribute to the repertoire of devices used to anticipate possible rebuttals, and their study can help reveal how writers move between grounds and claims in the process of gaining reader ratification for statements.

This study also has practical implications for the teaching of research writing in both L1 and L2 contexts, where the advice frequently given to students is to avoid hedging altogether (eg Winkler & McCuen, 1989: 97; Strunk & White, 1959:59). Many textbooks emphasise the impersonality of scientific discourse and encourage the idea that the goals, methods and topics of academic discourse transcend personality. The demands imposed by linguistic and rhetorical fluency in a second language, however, represent a major encumbrance for non-native English speakers studying science or seeking publication for their research (Gosden, 1992). Such demands may be responsible for the low level of NNS contributions to the scientific literature in English (Swales, 1985:42).

English is now the established lingua franca of scientific communication with perhaps 80% of the world's research output in English (Garfield, 1983). There can be little doubt that the ability to write effectively in English is a prerequisite for full participation in international research communities and of professional success. Scholars all over the world realise that publication in English guarantees the widest circulation for their ideas and the results of their research. However, the inadequacies of ESP materials on this topic (Hyland, 1994) underline why even otherwise proficient second language students find hedging their propositions notoriously problematic (Skelton, 1988a; Bloor & Bloor, 1991). Clearly, the more we understand such features of academic writing, the more we can assist NNS to participate fully and successfully in the research world.

The research may also provide analytic and descriptive insights that will enable teachers of English for Science and Technology (EST) to assist their students to write more effectively. The implications for English language teaching are therefore briefly discussed and suggestions made for teaching materials and approaches. This information may therefore be of relevance to teachers producing study materials to assist students with the pragmatic demands of hedging in scientific discourse.

A brief background to hedging

The concept of hedging is an area of some neglect (Crystal, 1995: 120) although the literature contains references to various aspects of hedging over the past 20 years. In fact, a plethora of labels demonstrates a continuing interest in

the topic. Hedges have been referred to as compromisers (James, 1983), downtoners (Quirk et al, 1972), weakeners (Brown & Levinson, 1987), downgraders (House & Kasper, 1981), softeners (Crystal & Davy, 1975), backgrounding terms (Low, 1996) and pragmatic devices (Stubbe & Holmes, 1995).

Hedging has received most attention in casual conversation where it is extremely common and represents a significant interpersonal and facilitative communicative resource for speakers (eg Stubbs, 1986; Coates, 1987). Speakers use hedges when they wish to create an informal or congenial atmosphere, facilitate turn-taking, sustain discussion, show politeness, mitigate face-threats or disguise deficient knowledge or vocabulary (Brown & Levinson, 1978; Coates, 1987 & 1988; Holmes, 1984; Turnbull & Saxton, 1997). Some writers also follow Lakoff (1972) in associating hedges with conveying purposive vagueness. Stubbs (1986) and Myers (1989) have argued that claiming precision is only appropriate in some situations and Latour & Woolgar (1979: 75-87), Powell (1985), Dubois (1987) and Channell (1990 & 1994) all claim that deliberate imprecision is a characteristic of academic discourse. Hedging has also been seen as a means of signalling the distance between a speaker and what is said (Prince et al, 1982; Rounds, 1982; Nash, 1990; Skelton, 1988b), and as a means to structure organisational roles and negotiate discourse statuses (He, 1993).

From the readers' perspective, hedges have been found to be an important element of persuasive writing (Conner & Lauer, 1988), although the extent to which it is attended to in different genres is uncertain. Low's (1996) evidence suggests that hedges may be 'lexically invisible' to respondents when included in questionnaire statements, while Crismore and Vande Kopple (1988) found that hedges presented impersonal voice and in low intensity enhanced students' memorisation of a text.

Hedges have also been treated as a form of 'metadiscourse' by some Applied Linguists who have included it in the elements of a text used to explicitly organise the discourse, engage the audience and signal the writer's attitude (Crismore & Farnsworth, 1990; Crismore et al, 1993; Hyland, 1998 & in press a; Vande Kopple, 1985).

Metadiscourse refers to non-propositional aspects of texts which "bracket the discourse organisation and the expressive implication of what is being said" (Schiffrin, 1980: 231). Together with textual and attitude markers, hedges enable authors to project themselves into their work to signal their communicative intentions. They are therefore seen as a means of indicating the writer's

stance towards both the material and the reader. Hedges constitute an important feature of the metadiscourse in various kinds of persuasive prose of various kinds (Crismore & Farnsworth, 1989; Hyland, 1998), and are the most significant aspect of interpersonal metadiscourse in academic articles in a number of disciplines and in undergraduate textbooks (Hyland, in press a & b). This view of 'metadiscourse' therefore acknowledges a critical aspect of interactive discourse and alerts us to an important rhetorical feature of science RAs.

Analyses of written academic corpora have revealed some of the characteristics of hedging in text-books (Hyland, in press b; Myers, 1992), economic forecasting (Pindi & Bloor, 1987; Bloor & Bloor, 1993), science digests (Fahnestock, 1986), abstracts (Rounds, 1982), medical discourse (Salager-Meyer, 1994; Skelton, 1997) and molecular genetics articles (Myers, 1989 & 1990). Studies have also shown the importance to academic discourse in general of modal verbs (Hanania & Akhtar, 1985; Butler, 1990), imprecise numeric expressions (Channell, 1990; Dubois, 1987) and "commentative" items (Adams-Smith, 1984; Skelton, 1988 & 1997). More generally, hedges have been seen as an important means by which the values of scientific cultures are articulated in discourse meanings (Hyland, 1997). Together this literature has demonstrated the clear pragmatic importance of hedging as a discoursal resource for expressing uncertainty, scepticism and displaying an open mind about one's propositions.

Purpose and methodology

Unfortunately, while the literature places the importance of hedging beyond dispute, we know little about its frequency, distribution or use in different disciplines or genres. Almost no work has been carried out into the expression and functions of mitigation in academic contexts based on analyses of adequate corpora and no convincing account of its use in scientific writing exists. Much of the attention it has attracted has been of a theoretical nature, focusing on intuitive and decontextualised examples (Klinge, 1993; Lyons, 1977). Coates (1983) and Palmer (1990) focus only on modal verbs and draw on non-academic sources while Holmes (1988b) examines expressions of certainty as well as mitigation. Hedging in scientific research writing therefore represents a little studied area of pragmatic competence. In particular, greater attention needs to be paid to the fact that hedging represents a writer's *attitude* within a

particular context. There is, therefore, a need for an explanatory framework which accounts for its pervasiveness in academic discourse by situating hedging in its socio-pragmatic contexts.

The study was therefore undertaken to provide a comprehensive description of this feature in one particular context, the discourse of a major scientific discipline, by relating a systematic analysis of linguistic forms to a pragmatic explanation for their use. The research therefore helps situate the concept of hedging within wider argumentative strategies based on an analysis of authentic sources. In particular, the study seeks to identify the major hedging devices used in cell and molecular biology articles, determine their distribution across different rhetorical sections, explore their pragmatic functions, and to briefly compare the overall findings with other forms of academic writing.

To achieve these objectives, I will seek answers to the following questions:

1. Which lexico-grammatical forms and strategies are principally used to hedge in the corpus and do these differ from other forms of discourse?
2. Are hedges equally distributed across the rhetorical structure of the genre?
3. Are there clear pragmatic functions which hedges perform in science research articles and do these differ from other kinds of discourse?
4. Can particular hedging forms and strategies be related to particular rhetorical functions?
5. Do these findings suggest any particular teaching strategies and materials ?

In exploring these issues I draw on theoretical work on epistemic modality and extends studies in pragmatics, composition, applied linguistics and the sociology of science. It examines the rhetorical and professional contexts in which scientists work and which motivate the use of hedging, and analyses 26 research articles in cell and molecular biology. In addition, data from three large computer corpora of academic English, equivalent to over 2, 000 pages of text, are examined to determine differences in the frequencies and range of hedging expressions used. The book therefore moves from a discussion of the social and discursive practices of biologists to focus more explicitly on hedging. A detailed description of surface features of hedging in the corpus is then followed by a functional rationale for their selection and distribution. This procedure avoids a reliance on predetermined notional categories, so that an ex-

planatory framework can emerge from an analysis of actual language behaviour.

The study shows that the core function of hedging in science is a negotiation of meaning which seeks to balance reader and writer perspectives in gaining accreditation for knowledge claims. So, while the study of modality traditionally falls within the domains of linguistics and semantics, linguistic knowledge alone is insufficient to understand how discourse is rhetorically and stylistically organised. Texts must be seen as constituting a social dialogue between writers and readers within the wider context of social and discursive practices of the scientific discourse community. Together, the analyses demonstrate that hedging is a major aspect of academic argument and confirms its centrality to both individual scientists and to science itself. Ultimately, research articles reveal a relationship between a discourse community, standards of knowledge and textual representations and it is these in combination which clarify the use of hedges.

2. Towards a context of scientific hedging

Any attempt to provide a detailed analysis of how hedging is deployed as a constitutive feature of scientific writing needs to offer a characterisation of the settings within which it is used. Hedging cannot be properly understood, appropriately interpreted or relevantly described without going beyond the event itself. Language is a type of social practice and texts result from the actions of socially situated writers operating within particular institutional constraints. In other words, attention to hedging requires some understanding of the cultural practices of scientists and their epistemological assumptions and values, together with the specific genre within which the feature is situated and has significance. Context is thus seen here as an interactive and dialogic notion, both sustaining and sustained by the discourse of social actors at a given point of time. This chapter therefore turns briefly from a focus on hedging to look at the social institution of science and the particular discoursal activities and purposes of its practitioners. It seeks to provide an overview of relevant research to locate hedging in the wider context of our knowledge of scientific discourse and of scientific communities

The links between academic communities and their discourses have mainly been studied from two perspectives. Applied linguists have largely focused on the informational, rhetorical and stylistic organisation of written texts for pedagogic purposes, while sociological studies have sought to explore the interactions between scientists for evidence of the processes which maintain social order.

A major focus of the sociological work has been to examine the practices by which knowledge is socially constructed. This has revealed the influence of contingent factors in scientific research, and the rhetorical nature of the "empiricist repertoire" by which scientists persuade colleagues of their claims. This work has illuminated the central roles of power, allegiance, and self-

esteem in scientific cultures, and shown how researchers selectively draw on a range of potential accounts to explain their results. Linguistic approaches, on the other hand, have long recognised that texts are both interactive and situated within particular social contexts which constrain discourse choices. Recent research into scientific texts has focused on the rhetorical function of surface features or generic structure and has revealed a great deal about the interactions between text producers and their discourse communities.

The sociological accounts have therefore emphasised that linguistic conventions help to generate a social world of science without describing the systematic means by which this is accomplished, while the linguistic work has largely neglected the significance of the wider context in which linguistic features occur. Together, however, the two approaches offer considerable insights into the context of scientific research writing and describe how discursive practices are derived from and constrained by scientific cultures. The analysis of discourse invites questions about what certain choices accomplish in a text, and the purposes achieved by selecting particular options over others, although textual analyses alone cannot provide a rationale for such choices. Equally, particular representations of the nature of institutional and social relations require discoursal evidence, as the socio-rhetorical functions of language must be systematically grounded in linguistic description. An adequate account of an academic hedging thus requires an understanding of how the features of scientific discourse represent and produce disciplinary practices, while contributing to situated forms of argument.

In this chapter, then, I will first explore the discursive practices of text production and interpretation and the institutional and social circumstances which surround it. Then I will look more closely at scientific argumentation and the genre of the research article itself. Finally I will briefly characterise salient aspects of the context in which hedging needs to be understood.

Empirical and rhetorical models of scientific writing

It is a common belief that scientific discourse simply reports or describes natural facts with almost no human intervention. In a strictly empiricist view, a scientific text is regarded as a neutral descriptive medium which allows a scientist to act simply as "a messenger relaying the truth from nature" (Gilbert, 1976: 285). Research findings in the natural sciences are generally communicated in

research papers which follow a conventional style and 4- part IMRD format. This format now represents "the standard product of the knowledge manufacturing industry" (Swales, 1987: 42) and typically omits descriptions of wrong turns, false leads, unsuccessful procedures, and often the factors that resulted in the choice of problem or methods. It also ostensibly excludes reference to the author's opinions, doubts and interests and removes any allusion to the author's identity.

The effect of these stylistic devices is to maintain the assumption of an objective reality with an existence quite separate from the investigating scientist. The production of knowledge and its communication are presented as different activities. In following the correct procedures for revealing the truth, the researcher can appear to allow the truth to speak for itself. This involves presenting a research narrative, sometimes referred to as a 'phony story' (Berkenkotter & Huckin, 1995), which reinforces a view of scientific activity as collective, inductive and cumulative. Sir Peter Medawar, who shared the Nobel prize for physiology in 1960, has observed that RAs do "not merely conceal but misrepresent the reasoning that goes into the work they describe" (in Judson, 1995:34). The view of the scientist-researcher completing lab experiments then writing up the research according to a strictly circumscribed format is a modern myth which acts to bolster this normative view of scientific activity, and underline the objectivity of scientific knowledge.

In reporting new experiments and seeking endorsement of claims, RAs also demonstrate how disciplines exercise control over approved knowledge. Although it suggests an objective reality independent of the researcher, the research article reflects forms of culturally determined and socially agreed knowledge. A growing number of sociological studies have shown that scientific discourse is both socially situated and structured to accomplish rhetorical objectives (Bazerman & Paradis, 1991; Fahnestock, 1986; Gilbert & Mulkay, 1984; Myers, 1990). Persuading readers to accept a particular observation as a fact involves relying on a social consensus about how best to represent experiments, contextualise results, and present claims. Writers have to consider an expected audience and anticipate its background knowledge, processing problems and reactions to the text. Simultaneously, readers are trying to predict lines of thought and interrogate authors on their positions. Bazerman (1985), for example, has shown how physicists' reading processes reveal personal schema based on their active research purposes. All articles are evaluated for usefulness and importance and the paper that is unused and uncited receives

harsh judgement. In such circumstances the ability to anticipate the reader's needs, interests and schema are critical.

In fact, scientific language serves two main functions. It both assists the interests of competing scientists and research groups in procuring assent to propositions about the world, and it establishes and maintains the authority of science itself. Principally, rhetorical objectives involve persuading readers that a particular observation actually lies beyond questions of persuasion and is situated within the realm of fact. What counts as a fact however is grounded in disciplinary values and practices transmitted through socialisation and secured via a system of peer review. In other words, scientific knowledge is seen to be socially contingent and scientific discourse to be a rhetorical artifact.

Studies of research practices tell us a great deal about the importance of writing among the scientific community and about the conventions that constrain its patterns of discourse. An important aspect of this is the tension between the private aspects of experimental practices and science as legitimate public knowledge, discussed as different registers, or "interpretative repertoires" (Latour & Woolgar, 1979; McKinlay and Potter, 1987). Gilbert & Mulkay show that scientists routinely use two alternative ways of accounting for the same phenomena, referring to an "empiricist repertoire", which emphasises impersonal statements of evidence and experimental practices, and the "contingent repertoire", which acknowledges personal or social factors. James Watson's (1968) discussion of the events leading to the discovery of the DNA structure is a good account of how chance, competition and deception can play a role in research. In more recent times, one of the informants interviewed for this study cited the role of self-interest in maintaining the massively funded research "bandwagon" into the greenhouse gasses effects.

It is unsurprising that the choice of register often varies systematically with context, but while the former is common in the research literature and the latter in informal conversation, writers can shift strategically between the two. The account that is selected is directly employed to bolster scientific claims and so scientists will typically employ an empiricist repertoire to account for their own work and give versions of their opponents' research in contingent terms, drawing attention to the potential influence of distorting social and personal factors. But while this strategy has been observed in forums such as conference presentations (McKinlay & Potter, 1987), and published papers (Yearley, 1981), it rarely involves specific attacks accusing particular individuals of bias or incompetence. Explicit refutation is rare, and writers typically hedge their

criticisms and manage conflict through acceptable channels (Bazerman, 1988, chap. 5). This kind of hedging is central to the norms of rhetoric advocated by Boyle 300 years ago. Boyle argued that disputes should refer to findings rather than their supporters "for I love to speak of persons with civility, though of things with freedom" (quoted in Shapin, 1984: 502). Such appropriate scientific rules of discourse allow disputants to express divergent (appropriately hedged) views while contributing to the growth of knowledge.

How the empiricist repertoire is used to characterise scientific practices is illustrated by Knorr-Cetina's (1981) description of the way lab work is differently represented in published accounts. The sequence of Introduction, Method, Results and Discussion (IMRD) falsely suggests that laboratory activity proceeds in a unidirectional, systematic fashion of experiment- result- interpretation- conclusion. Science rarely proceeds like that however. One informant put it thus:

> The whole business is to do with serendipity in a sense, because while
> you set out expecting to find something, in many cases discoveries are
> made by chance, just where you're not looking. You have to be aware of
> this, of course, to find something when it occurs.

In Knorr-Cetina's study the research team responded to a propitious laboratory finding rather than consciously solved a stated problem. By reversing the research events in terms of a problem-solution dynamic however, the writers were able to reformulate the activity as extracting potato protein by an efficient new method and depict their results as a contribution to experimental technique.

This conventional IMRD organisation of the research article has been discussed by Gross (1985) as a rhetorical device which helps justify the enterprise of experimental science. The form of the research paper, moving "from the contingency of laboratory events to the necessity of natural processes" (ibid. p 20), is designed less to explore research issues than to perpetuate the myth that the process of induction, upon which science relies for the certainty of its knowledge, is unproblematic. The Introduction places the experiment in the context of a research programme rather than laboratory events, thus creating a theoretical rather than contingent interpretive world, and this process is continued in Methods and Results where the objectivity of laboratory practices is emphasised over contingencies of human activities. Finally, the Discussion frames the relevance of these practices in the theoretical perspective of the Introduction, emphasising a correspondence of the data to the paper's claim. The

research article thus leads from sensory experience to reliable knowledge, creating a uniform interpretive context.

Moreover, not only are a paper's proposed conclusions made to appear as if they followed unproblematically from empirical evidence, but rhetorical decisions also intervene when scientists revise successive drafts of a paper for publication. Myers' (1990) case studies of two biologists attempting to get research funded and published, shows how significant alterations are made in the conceptual organisation and macro-structure of papers. Claims become more cautious, speculations and proposals more restricted and a discursive text replaces a more goal-directed one. There is also a considerable increase in hedging in the final versions as authors anticipate the text's reception in the discourse community and try and place their claims appropriately within it. The writing of a research article thus involves selective representation and rhetorical reconstruction as a means of anticipating negative responses to claims. Such processes as an after-the-fact reconstruction of a goal-directed purpose in the literature review, a procedural account of the methodology and a selective narrative of results are all means of persuasively presenting the writer's knowledge claims as unproblematically related to observed data.

While scientific discourse reflects disciplinary needs for a convincing rhetorical style, we cannot deny the importance of an epistemological system founded on the possibility of direct and reliable knowledge of the natural world. Experimental science has evolved at least partly as a result of beliefs that correct inductive procedures can reveal apodictic truths about reality, and all the biologists interviewed for this research strongly subscribed to the view that there was an external world which could be understood using scientifically appropriate means. However, an empiricist position cannot convincingly explain the evolution of the formal and terminological stability of scientific prose, nor the basic contradictions of inductive procedures in its production.

Importantly, these familiar ways of discussing nature, which seem a timeless and self evident means of establishing and defending knowledge, have in actuality been consciously developed historically in response to particular rhetorical situations. The conventional linguistic practices for expounding and securing support for scientific knowledge are historical artifacts which date from the 1600s (Shapin, 1984). Establishing rules of discourse to generate and validate authentic facts and to create a "public" for experimental research was crucial when science was in its infancy. The literary technology of Robert Boyle and his colleagues served to both proselytise and create linguistic

boundaries which segregated authenticated facts from man-made hypotheses, producing the "illusion that scientists' speech about natural reality is simply a reflection of that reality" (Shapin, 1984: 510).

By avoiding unfounded speculation, providing elaborate accounts of both successful and failed experiments, giving detailed illustrations, and employing devices which distinguished "matters of fact" from speculations, Boyle helped create a rhetoric which laid the foundations for scientific communication. One of the most important linguistic devices of this rhetoric of science was the use of what we now call 'hedges'. As Boyle states:

> in almost every one of the following essays I ... speak so doubtingly, and use so often, 'perhaps', 'it seems', it is not improbable' and other such expressions, as argue a diffidence of the truth of the opinions I incline to ...
>
> (in Shapin, 1984: 495)

Only facts, as discovered rather than invented, could be spoken of assuredly, "...I dare speak confidently and positively of very few things, except of matters of fact" (ibid p 496). A clear distinction between facts and interpretation was recommended, both in terms of a moral stance and manner of speech to provide the basis of an embryonic scientific philosophy and academic discourse.

The development of scientific prose to the present has been traced by Atkinson's (1996) survey of *The Philosophical Transactions of the Royal Society of London* between 1675 and 1975. This shows how linguistic practices, particularly those relating to changes in the presentation of experiments, were increasingly refined. This enabled contributors to gain publicity and acceptance for their work and for figures like Boyle, Hooke and Newton to become public figures through regular publication. As publication became essential to science and audiences became increasingly professional, critical and research-motivated, a communication network of scientists evolved which required institutionalised standards of public argument, moving from author-centred norms of genteel conduct and deductive reasoning to a greater attention to methodology and experimental research. Such changes were in response to evolving research communities and represented a movement away from the observations of gentlemen to the evolution of specialist disciplines and research problems.

The subsequent de-emphasising of methods and the substantial expansion of theoretical discussions in this century further point to changes in rhetorical and social practices (Atkinson, 1996; Bazerman, 1988; Berkenkotter & Huckin, 1995). The reasons for the emergence of Discussion to replace Methods as the

dominant basis of persuasion is uncertain, but is probably related to the standardisation of experimental procedures and the greater need to contextualise scientific work in terms of discipline recognised problems and a community generated literature. Critically, scientific communication builds on prior texts, and "common theory has become an extremely strong force in structuring articles and binding articles to each other" (Bazerman, 1988: 157). The explosive growth in scientific research to address these problems and the increasing pressure to publish findings has also resulted in the development of the RA as a 'promotional' genre. This discourse emphasises features such as titles, abstracts and graphics to foreground novelty and significance, to accommodate the scanning reading patterns of information saturated readers searching rapidly for relevance and novelty (Bazerman, 1988; Berkenkotter & Huckin, 1995: Ch 2).

The changes noted in these studies suggest that RAs are strongly responsive to changing disciplinary norms and the ways community members consume texts. Thus the means by which arguments are presented, procedures enumerated, literature cited, theory and data discussed, can only be seen as effectively persuasive against a backdrop of disciplinary practices and rhetorical expectations. The development of a scientific community has helped codify the language of scientific presentation we see today as a result of a need to socially validate knowledge. This discourse community has achieved a relatively stable rhetorical situation in order to discuss similar topics under similar conditions, for similar purposes. Readers therefore not only share an acceptance of a great deal of knowledge of content and methods, they also share an acceptance of a pattern of discourse which has evolved in response to particular rhetorical contexts.

Texts play many roles in the scientific community but the norms of discourse and writers' conformity to them suggest a strong common goal. Each new paper is based on the existing consensus among scientists and seeks to become part of that consensus. The strong continuity of language and discourse forms and the heavy citation of previous work demonstrate the dependency of argument on this process, while the impersonality of voice and the use of technical lexis illustrate attempts by the new contribution to insinuate itself into this body of agreed knowledge. Formal text features represent fundamental relations among scientists and are the result of a number of considerations, which are commonly cited as respect for reason, accuracy, truthfulness, humility, universalism, efficient ways of representing nature, and so on. The importance of persuasion in scientific discourse, however, also indicates that language serves

the competitive interests of separate individuals and research groups, and is partisan and argumentative. Scientific language cannot, as a human artifact, be a dispassionate, objective representation of nature. Rather, it serves personal goals for authors, institutions and the discipline itself.

One reason given for the use of persuasive rhetoric is that scientific publication is a route to a range of tangible rewards which satisfy the specific wants of individuals in the scientific community:

> The academic science community operates an institutionalised system which is simultaneously a communication system and a reward system and what might be called a system for 'distributing property'. This system rests on peer judgement.   (Barnes & Edge, 1982: 15)

A scientist's contribution is judged by colleagues who are potentially able to make use of it. If they judge it to be significant, grant it publication, borrow and cite it, then the scientist achieves recognition. This may lead to tenure, promotion, research funding or a Nobel Prize. Latour and Woolgar (1979) argue that a scientist's goal is to maximise credibility in the discourse community. Credibility can then be used as credit in a series of moves which allows them, through grants, equipment, more data and fresh publications, to increase their credibility further. The apparent objectivity of scientific papers is therefore seen as compromised by the fact that they are principally contributions to professional reputations in a forum of competitive publication. As Gaston (1971) writes:

> In their attempts to gain recognition for their accomplishments scientists work in a competitive situation which is quite different from that of other professions ... Competition in science is more like a race between runners in the same track and over the same distance at the same time.

Communication facilitates the social interactions which assist in the production of knowledge and, as Berkenkotter and Huckin (1995: 1) observe, this is vital to institutions and individuals:

> ....maintaining the production of knowledge is crucial for institutional recognition, the development of sub-specialties, and the advancement of scientists' and scholars' research programs. Scientific and scholarly productivity are also the criteria by which careers are assessed, tenure given and grants awarded.

Authors want to see their papers published in prestigious journals that testify to the importance of their claims, help promote their reputations among peers, and provide support for their related proposals for research funding (Myers, 1990). The need for recognition and reward among active researchers then, is a principle motivation for publishing research and a principle reason for the essentially rhetorical character of the research article.

Research writing as social action

The scientific paper emerges from the research reported above as a rhetorically competent product through which scientific knowledge is negotiated and ratified. Language is seen as central to members of scientific communities in gaining acceptance for their claims, as it is the means by which arguments are presented and opposition anticipated. A successful claim thus depends on linguistic choices which appropriately convey the writer's intention, facilitate the smooth exchange of information and create conditions for persuading readers of a point of view. Speech act theory offers some useful insights into how this may be accomplished, as it challenges a view that comprehension is simply dependent on an interpretation of words on the page. It both confirms our conviction that purposes underpin actions, and suggests a means of analysing rhetorical acts as social accomplishments which involve shared writer-reader knowledge of disciplinary discourse conventions.

The translation of words into acts is only possible within the structure of a particular discourse since, the decisive function of any sentence depends on a framework of understandings about the text to which it contributes, together with the expectations established by a particular discourse community. Austin's (1962) distinction between propositional (locutionary) meanings, functional (illocutionary) meanings and the interlocutor's response to these acts (perlocutionary effects) is well known. For our purposes its relevance lies in the fact it facilitate a principled division between meanings which convey information clearly and those which are effectively persuasive.

For speech act theorists, argumentation can be seen as an "illocutionary act complex composed of elementary illocutions" (Van Eemeren and Grootendorst, 1984: 39). These elementary illocutions are to be found within Searle's (1979) category of *Assertions*[1] which commit the writer to the truth of the expressed proposition and include acts such as asserting, suggesting, claiming,

reporting and so on. Essentially then, speech act theorists might see a scientific text as a constellation of illocutionary acts which constitutes an argument by justifying or refuting a given opinion. The purpose of such argumentation is to elicit from readers a particular response: writers hope they will be convinced or persuaded. For Van Eemeren and Grootendorst, this means the language used must serve both a communicative and an interactional purpose, a writer not only wants the words to be understood (an illocutionary effect), but also to be accepted (a perlocutionary effect). The reader is expected to rationally decide whether to accept the perlocutionary effect desired by the writer, but the illocutionary effect of understanding an argument is not a sufficient condition to achieve this.

The principal insight of speech act theory therefore is that linguistic communication involves not only surface forms but also the reader's recognition of the writer's intention in the context of the discourse. In writing up their research, scientists convey propositional content and perform illocutionary acts by expressing at least one attitude which reflexively intends the reader to understand that he or she has that attitude. These examples from my corpus help make this clear:

(1) The proposed model reconciles a number of observations and data already in the literature for which a cohesive theory was previously lacking.
(A1:274)

(2) These results demonstrate that Arabidopsis produces at least two classes of screening pigments that reduce UV-B damage: flavonoids and sinapate esters.   (D3:176)

In performing the illocutionary act of asserting by making a claim for a model (1), or stating a result (2), these writers have firmly expressed their intent in performing such an act by using appropriate syntactic forms (declaratives). This signals both their belief in the truth of the propositions and their intention that readers should believe that they believe the propositions are true. The illocutionary act is accomplished by readers recognising that intention, and communication is achieved by them experiencing this "illocutionary effect" (Searle) or "uptake" (Austin).

The accomplishment of social acts in scientific writing therefore concerns epistemic change; the intention of the writer is to alter the knowledge set