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Talking to the academy: forms of hedging in science research articles

## Abstract

Hedging refers to linguistic strategies which qualify categorical commitment, expressing possibility rather than certainty. In scientific writing hedging is central to effective argument and the rhetorical means of gaining reader acceptance of claims, allowing writers to convey their attitude to the truth of their statements and anticipate possible objections. Because they allow writers to express claims with precision, caution and modesty, hedges are a significant resource for academics. However, little is known about the way hedging is typically expressed in particular domains nor the particular functions it serves in different genres. This paper identifies the major forms, functions and distribution of hedges in a corpus of 26 molecular biology research articles and describes the importance of hedging in this genre.

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## Talking to the academy: forms of hedging in science research articles

### 1. Introduction

The notion of hedging has been around since the term was first used by Lakoff (1972: 195) to describe “words whose job it is to make things more or less fuzzy” and has subsequently been applied to caveats such as ‘I think’, ‘perhaps’, ‘might’ and ‘maybe’ which we routinely use to qualify categorical assertions. A hedge is therefore any linguistic means used to indicate either a) a lack of complete commitment to the truth of a proposition or b) a desire not to express that commitment categorically. Hedges express tentativeness and possibility in communication, and their appropriate use in scientific discourse is vital.

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 an important means by which professional scientists confirm their membership of research communities and its study has important implications for a number of areas. Unfortunately, while the literature confirms its importance, we know little about how hedging is typically realised in different domains. Almost no work has been carried out into the expression and functions of mitigation in academic contexts based on analyses of adequate corpora.

Much of the work on modality has been theoretical (eg Lyons, 1977) while corpus studies have tended to either focus on modal verbs and draw on non-academic sources (Coates, 1983; Palmer, 1990) or examine expressions of certainty as well as mitigation (Holmes, 1988). Studies of written academic corpora have either been confined to generalised “commentative” items (Adams Smith, 1984; Skelton, 1988), abstracts (Rounds, 1982), modal verbs (Hanania & Akhtar, 1985; Butler, 1990), numerical expressions (Channell, 1990; Dubois, 1987) or to situating hedges in pre-determined explanatory categories (Salager-Meyer, 1994). As a result there are significant gaps in our knowledge of this important area of pragmatic competence.

A better understanding of how hedges are used in scientific research articles (RAs) 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 distinguished by its role in reporting new experiments (eg Swales,

1990) and is the major vehicle for knowledge in academic cultures, central to the legitimization of a discipline and the reputations of its practitioners. This importance has been confirmed by sociological studies which have debated the epistemological basis of scientific knowledge.

These studies view the RA as a significant rhetorical artefact, which acts to both conceal the contingency of knowledge and persuade for the acceptance of claims (eg Latour & Woolgar, 1979; Bazerman, 1988). This sociological research sees scientific knowledge as less a coherent body of objective truth about the world than a set of justifiable beliefs constructed through interactions among members of the scientific community. 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 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 motivates the expression of doubt and tentativeness in science for interpretations of levels of certainty can help secure readers' acceptance. Hedges are an important rhetorical device in academic writing as they signal the writer's anticipation of opposition to claims.

Information about hedging can also contribute to our understanding of the practice of evidential reasoning and the structure of argumentation discussed by Toulmin (1958), Longino (1990) and others. Toulmin's 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 often given to students is to avoid hedging altogether (eg Winkler & McCuen, 1989: 97; Strunk & White, 1959:59). English now dominates academic

communication with perhaps 80% of the world's scientific research output in English (Garfield, 1983). The ability to write effectively in English is therefore a prerequisite for full participation in the international research community. However, the inadequacy of ESP materials on this topic (Hyland, 1994) helps explain the fact that even otherwise proficient L2 students find hedging their propositions notoriously problematic (Skelton, 1988; Bloor & Bloor, 1991). Clearly, the more we understand such features of scientific writing the more we can assist both NSs and NNSs to participate successfully in the research world.

This study sets out to characterise the role of hedging in cell and molecular biology research articles. It seeks to clarify the incidence and function of particular expressions and provide baseline data for studies of other fields and of the evolution of key genres. After some preliminaries, I begin with a brief outline of the rhetorical functions of hedging in RAs before describing its realisation in some detail, discussing the frequency, expression and distribution of forms, and finally drawing tentative connections between forms and functions in this genre.

## 2. Previous work on hedges

The concept of hedging has received most attention in casual conversation where it is possibly twice as frequent as in written discourse and represents a significant communicative resource (eg Stubbs, 1986; Coates, 1987). Speakers are said to use hedges when they wish to create an informal or convivial atmosphere, facilitate discussion, show politeness or disguise a deficit of knowledge or vocabulary (Holmes, 1984; Coates, 1987). Some writers follow Lakoff (1972) in associating hedges with conveying purposive vagueness (Latour & Woolgar, 1979: 75-87; Powell, 1985; Dubois, 1987; Channell, 1994), while Stubbs (1986) and Myers (1989) argue that precision is not always contextually appropriate. Hedging has also been seen as a means of distancing a speaker from a statement (Prince et al, 1982; Rounds, 1982; Skelton, 1988) and of structuring organisational roles and negotiating discourse statuses (He, 1993).

Hedges have also been treated as a form of 'metadiscourse' by some applied linguists who have widened the concept beyond features of textual organisation to include elements such as

the writer's attitudes and expression of certainty (eg. Vande Kopple, 1985; Crismore & Farnsworth, 1990; Crismore et al, 1993). This terminological extension draws attention to items which direct readers to how they should understand, evaluate and respond to propositional information. These are functions which are important rhetorical means of both supporting the writer's position and building a relationship with an audience in RAs.

### 3. Description of the study

The study is based on a corpus of 75, 000 words taken from 26 research articles in cell and molecular biology, a key discipline for L2 research students. The RAs were written in English and appeared in the six leading journals in the field based on the views of expert informants and reference to the Journal Citation Reports (SCI, 1993). The JCR ranks each journal according to the times it is cited in a particular year, and therefore the likelihood of it being read by researchers in a given field. A selection of recent articles from these journals provided "prototypical exemplars" of the genre (Swales, 1990: 58) which fulfil the typical expectations of the parent community. Letters, notes, reviews and abstracts were ignored.

The results of the analysis were compared with general academic data taken from three large computer corpora. These were a sample from the JDEST corpus, a variety of genres from different fields of science and technology, and the 'J' sections of the Brown and LOB corpora, which are comprised of heterogeneous academic genres and disciplines. Together these produced 780, 000 words, equivalent to over 2, 000 pages of text.

The procedure first identified a list of possible linguistic items used to express hedging from the research literature (eg Perkins, 1983; Kennedy, 1987; Holmes, 1988). Holmes' work, for example, indicates the importance of lexical verbs such as 'appear', 'assume' and 'suggest' in academic discourse, while Kennedy shows that tentative expressions such as 'infrequently' and 'on occasion' do not occur at all. Occurrences of these devices in the RAs were examined in context to ensure they expressed a hedging function and coded according to grammatical classes and categories specific to the genre. The academic corpora were then computer scanned to produce frequencies of the target items. A key word concordance, which places the item in a 20-word context, was performed on a large sample of the modal

verbs and other items to ensure that each use hedged writer commitment.

#### 4. The functions of hedging in scientific writing

My data reveals two major functions of hedging in scientific writing which I have called content-motivated and reader-motivated. Both acknowledge the critical role readers play in ratifying knowledge as they signal the writer's anticipation of the negatability of claims. While scientific statements require reader ratification, and writers actively seek this, readers always have the right to refute claims. Essentially, this opposition can be divided into two types. Firstly, claims have to meet adequacy conditions, they must correspond to what is thought to be true according to beliefs about the nature of external reality. Secondly, they have to incorporate an awareness of interpersonal factors, meeting acceptability conditions. Writers must therefore make assumptions about the nature of reality (content-motivation) and the acceptability of a statement to an audience (reader-motivation), as only claims which seem to be objectively legitimate and sensitive to audience expectations are likely to be ratified.

Hedging devices are, however, polypragmatic in that they convey a range of different functions simultaneously. This indeterminacy means there is inevitably some overlap between the two groups, ie. cases assigned to one category will include meanings associated with the other, and a precise motivation may not always be clear. A theory of fuzzy sets with graded membership, rather than a traditional analysis based on discrete semantic categories, therefore offers a better explanatory model (Zadeh, 1972; Coates, 1983). Core examples will therefore approximate to the pragmatic meaning of a particular category while expressions at the periphery will exhibit meanings associated with another category. The resulting ambiguity may of course be a strategic option for writers when presenting information.

##### 4.1. Content-motivated hedges.

Content-motivated hedges mitigate the relationship between what the writer says about the world and what the world is thought to be like. They involve either a concern with the need to present claims as accurately as possible or to anticipate what may be harmful to the writer. While there may be an element of each purpose on any particular occasion of use, the contexts in which they occur often help distinguish them.

Accuracy-based hedges allow writers to express propositions with greater precision and caution in areas characterised by shifting interpretations (eg Prince et al, 1982; Rounds, 1982; Skelton, 1988; Thompson, 1993). Scientific writing always seeks to balance fact with judgment as writers try to present information as fully, objectively and accurately as they can. Hedges here distinguish the actual from the inferential and imply that a proposition is based on the writer's plausible reasoning rather than reliable facts. They therefore specify the state of knowledge on a subject, either by defining how statements are to be understood (1 & 2) or by accurately asserting the writer's assessment of the certainty of the proposition (3 & 4).

- (1) Staining was generally confined to the vascular tissues ...
- (2) The proteolysis of PEPc was almost completely prevented by the inclusion of....
- (3) Such a mechanism might serve to balance the synthesis of the products ...
- (4) The most hydrophobic of these external loops is a probable candidate for ...

Readers are expected to understand that the proposition is true as far as can be determined.

Writer-based hedges concern the writers desire to anticipate possible negative consequences of being proved wrong by limiting commitment to claims, blurring the relationship between a writer and his/her proposition (Prince et al, 1982; Powell, 1985; Nash, 1990; Swales, 1990). Scientists gain credibility by stating the strongest claims they can for their evidence, but they also need to insure against overstatement. Hedges here enable writers to refer to speculative possibilities while alluding to personal doubt, avoiding personal responsibility for statements to protect their reputations and limit the damage which may result from categorical commitments. These contrast with accuracy-based hedges by diminishing the author's presence in the text rather than increasing the precision of claims. In such cases care is taken to avoid assuming direct personal responsibility for a claim, principally by the author concealing him or herself behind the syntax through use of passives, existential subjects (5) or 'abstract rhetors', which attribute claims to the text or data (6 & 7):

- (5) It seems that the stomata do not use the Calvin cycle ...
- (6) These data indicate that phytochrome A possesses the intrinsic ...
- (7) Thus the evidence strongly favours the conclusion that ...

A hedge can therefore steer a reader's interpretation away from a literal interpretation which



would be the case with an accuracy-motivated usage.

#### 4. 2 Reader-motivated hedges.

Hedges also contribute to developing a relationship with readers by addressing the need for deference and cooperation in gaining the ratification of claims. Hedging the illocutionary force of speech acts is common in conversation (Holmes, 1984) where it has been attributed to deference (eg Fraser, 1980) or politeness in avoiding threats to face (Brown & Levinson, 1987). Myers (1985; 1989) contends that this is also a motivation for hedges in scientific discourse where “claims of originality are risky and criticisms of opposing views can seldom be explicit” (1989: 238). However, there is little evidence of politeness in Myers’ sense in my corpus where the need to acknowledge the reader’s role in ratifying knowledge and conform to community limits on self-assurance outweigh issues of power or status. Simply, categorical assertions leave no room for dialogue, reject the need for feedback and consign the reader to a passive role. So here hedges appeal to readers as intelligent colleagues capable of deciding about the issues, and mark statements as merely provisional. This interpersonal role is reinforced by institutional obligations to engage in debate with fellow scientists.

While many devices are used to convey both writer and reader-based hedges, the latter usually involve the use of personal attribution which subtly hedges the universality of the writer’s claim by implying that a position is an individual interpretation. While impersonal expressions indicate a writer-focused hedge and a desire to guard against the possibility of error, explicit reference to the writer marks a statement as a personal opinion rather than a definitive statement of truth, merely an alternative view awaiting verification and allowing the reader to choose the best explanation:

- (8) In our hands, there was no significant change in  $V_{\max}$  on illumination.
- (9) I believe that the major organisational principle of thylakoids is that of ....
- (10) I suggest here that the photosynthetic apparatus in higher plants not only ...
- (11) My analogy is with a conveyor belt.

Reader acceptance is a powerful factor in the communal accreditation of knowledge and hedging here acknowledges both the reader’s role in negotiating the status of claims and the need to conform to expectations of modesty and appropriate deference to colleagues’ views.

So, like conversationalists, writers hedge to convey both referential and affective meanings. But there are important differences in the nature of these functions. In science hedging is predominantly an element of persuasion, enabling claims to be expressed with precision, caution and humility and writers to meet audience expectations of accuracy and negotiation.

## 5. Surface features of hedging

This section will discuss the expression and distribution of hedges in the corpus. I begin with an overview of the frequency of hedges in this genre then go on to discuss its lexical and strategic realisation and its distribution. The study shows that hedging is a significant aspect of scientific prose and that it is realised both lexically and by three main strategies. Scientific hedging is principally a lexical phenomenon, with 79% of cases realised by lexical verbs, adjectives, adverbs and modals, and seems to employ a more restricted range of items than found more generally in academic writing. In terms of distribution, almost half the hedges occur in groups of two or more, while its rhetorical distribution follows expected patterns for pragmatic devices with 84% occurring in the Results and Discussion sections.

### 5.1 The frequency of hedging

Given the pragmatic importance of hedging outlined above, it is not surprising to find scientific writing carefully and extensively hedged. Hedges represent more than one word in every 50 in my corpus and this frequency is supported by Skelton (1988), Adams Smith (1984) and Hanania & Akhtar (1985), all of whom found one epistemic comment every 2 or 3 sentences in their academic corpora. This suggests that hedges are more numerous than many features of scientific discourse which traditionally get much more attention in writing courses. Table 1 shows the frequency of hedging expressions by category.

\*\*\*\*\* INSERT TABLE 1 HERE \*\*\*\*\*

### 5.2 The expression of hedging

Despite linguists' preoccupation with modal verbs, a large number of different devices, both lexical and strategic, are used to express hedging. These will be discussed in turn.

### 5.2.1 Lexical hedges

Hedging is predominantly expressed lexically but the use of particular devices appears to differ across domains of use, as this comparison with Holmes' (1988) data for the academic sections of the Brown and LOB corpus and informal and semi-formal sections of the Lund corpus of English speech shows (Table 2). Biologists appear to make less use of modal verbs to express degrees of confidence, for example, and the use of both adjectival and adverbial items in scientific discourse is particularly striking when compared with academic writing more generally, which may be related to the high lexical density in scientific prose.

\*\*\*\*\* INSERT TABLE 2 HERE \*\*\*\*\*

The major forms of lexical hedging are discussed below.

#### 5.2.1.1 Modal verbs

The modal verbs are recognised to be polysemous (Coates, 1983; Perkins, 1983; Palmer, 1990) with hedging uses characterised by avoiding bald assertion. Epistemic uses appear to be far more frequent in informal speech and personal writing (Coates, 1983) and in lectures (Flowerdew, 1993) than in academic writing. In the RA corpus 'would', 'may' and 'could' account for 77% of the total hedging uses. Table 3 provides a comparison with other academic domains: a sample from the JDEST technology corpus mentioned above, Butler's (1990) findings from 12 hard science texts and Holmes (1988) general academic corpus.

\*\*\*\*\* INSERT TABLE 3 HERE \*\*\*\*\*

The highest densities are found in the Holmes' and JDEST samples, small corpora of diverse subject matter and genre, and may reflect the considerable differences in the distribution of particular modals between disciplines (Butler, 1990: 144). The frequency of 'will' is the main difference between the general academic corpora and the science material and this may be explained by the fact its hedging sense, to make predictions based on anticipated outcomes, is perhaps more suited to less cautious fields than the hard sciences. Butler's science material and the RA corpus display similar overall densities of epistemic forms and similar rankings for individual items with 'would', 'may' and 'might' figuring significantly. The clearest differences occur between the use of 'would' and 'may', which alter their rankings. The distribution of both modals shows considerable similarity however when

compared with the other corpora, with ‘would’, in particular, occurring far less often than in the mixed samples. Overall, scientific writing contains a lower density of modals and does not employ the full range of items to express epistemic meaning. Neither epistemic ‘shall’ (expressing expectation) nor ‘ought’ (tentative assumption) occur and there are significantly lower frequencies of ‘would’, ‘will’ and ‘must’.

### Could

Could expresses both hedging and ‘root possibility’, which concerns the role of enabling conditions on a proposition rather than the writer’s assessment of its truth. Distinguishing between the conceptually possible and the experientially possible is often problematic and may depend on access to the participants’ knowledge:

(12) It could also be demonstrated with both broken and intact chloroplasts.

(13) An increase in  $\text{NO}_3^-$  assimilation in the roots could function to provide additional N to the sheath where fungal growth is most extensive.

Such ambiguity between the writer’s tentative assessment of possibilities and the role of external circumstances enables writers to establish greater distance from their propositions.

### May and might

Figures for ‘might’ and ‘may’ are relatively consistent across the samples although ‘may’ is slightly more frequent in Butler’s smaller scientific corpus. Epistemic ‘may’ occurs over twice as often in print and is the only modal to figure notably more often in academic genres, perhaps because of its perceived formality. Both modals indicate a 50-50 assessment of possibilities, but some credence is given to the view that ‘might’ is a more tentative form than ‘may’, perhaps because the condition of realisation is more remote. It also occurs far more frequently in ‘harmonic combinations’ (Lyons, 1977: 807) with other epistemic items:

(14) One might speculate that what is now understood as carotenoid functions are not to be understood as common capabilities of all carotenoids.

(15) This insertion, which we suspect is the membrane anchor, could associate peripherally with the membrane or might span half the bilayer in a manner similar ...

Moreover, ‘might’ appears to be the preferred choice when the context allows either a root or

epistemic interpretation of ‘may’. Here it is the writer’s lack of confidence in the truth of the statement rather than enabling circumstances which is intended:

(16) Such a mechanism might serve to balance the synthesis of the products throughout this pathway in wild type Arabidopsis.

(17) This implies that the extent to which the endophyte might affect N metabolism under field conditions could also depend considerably upon other interacting factors.

### Would and should

‘Would’ and ‘should’ are the principal markers of hypotheticality. Epistemic ‘would’ as the hypothetical marker of predictive ‘will’ is common in my corpus, generally suggesting prior experimental premises and expressing the conditions required to fulfil the hypothesis.

Syntactically, most examples are active with ‘be’ the most frequent co-occurring main verb followed by ‘appear’ and ‘suggest’.

(18) ..if the haemoglobin in the root were mainly at the tip, it would have a local concentration 100-fold or greater than originally deduced.

(19) It would be very interesting indeed to study with their methods the proportions ...

‘Would’ is also used pragmatically, where it appears to attenuate a proposition unnecessarily and express caution rather than a genuine hypothesis. The use of ‘would’ in the following examples does not reduce writer commitment but softens categorical assertions and thereby avoids forcing the reader to comply with a forthright insistence of a claim.

(20) This result would favour the hypothesis that the plant protein is targeted to the bacteroids.

(21) Increased N economy would be consistent with observations that the endophyte decreases the effects of stress on growth and survival, ...

Examples of epistemic ‘would’ marking past tense ‘will’ occur less often in the corpus.

Epistemic ‘should’ typically refers to the future and consequently has a more tentative meaning than ‘would’, expressing a less confident assumption of probability based on known facts. It occurs far less often than ‘would’ in the data, although my findings agree with Butler in identifying a higher frequency than in other domains.

### Will and must

Neither of these forms are significant in science although they serve hedging functions by weakening confident assertion, by use of prediction and inference respectively. The use of ‘will’ in scientific writing usually refers to general truths, the justification for the assurance being based on repeated experience rather than logical inference:

- (22) If significant energy is lost by the plasma particles in this process, the plasma will be cooled.

Science writers often prefer ‘would’ to ‘will’ in discussing present time probabilities however. This is more conditional and can be used to express hypothetical predictions or tentative deductions and indicate less confidence in outcomes. It is therefore more appropriate in a forum where speculation and tentativeness is crucial.

- (23) The prediction of this model is that aminoxyisovalerates with aromatic rings characteristic of potent synthetic auxins would be good candidates for ....

Must is the predominant modal of inferential confidence in spoken discourse (eg Collins, 1991) although its relative infrequency in scientific discourse again suggests writers are reluctant to express even weak convictions when making deductions. It is often replaced in the journal corpus by epistemic ‘could’ which expresses tentative possibility. This is because of the speculative nature of scientific research compared with the greater proportion of digest and textbook material in the general academic corpora. Typical examples are:

- (24) Another conceivable reason for this decrease could be a change in TRP  $\tau_0$  value under the influence of the electric field induced by  $P^+$  and  $Q^-$  charges.
- (25) This implies that the extent to which the endophyte might affect N metabolism under field conditions could also depend considerably upon other interacting factors.

#### 5. 2.1.2 Epistemic lexical verbs

Lexical verbs form the largest group and greatest range of items with 38 different forms represented. *Indicate, suggest, appear* and *propose* constitute 56% of all instances and a comparison with the other academic corpora shows that all four verbs, and particularly *indicate* and *suggest*, occur far more often in scientific writing (Table 4). Distinctions of channel are also confirmed with the absence of common conversational hedges such as

‘guess’, ‘reckon’ and ‘think’.

\*\*\*\*\* INSERT TABLE 4 HERE \*\*\*\*\*

Once again hedging items were identified in context as marking less than full commitment to the truth of a proposition. Hedging verbs represent an overt means of displaying the subjectivity of the epistemic source and are generally used to either hedge commitment or assertiveness. Their numerical significance in scientific RAs reflects their rhetorical versatility in contexts where categorical assertions rarely represent the most effective means of expression. They contribute to the evidential reasoning between data and hypotheses as they are often used to express an assessment of the relationship between grounds and claims (Toulmin, 1958). With impersonal phrasings they indicate the writer’s lack of confidence and allow readers to evaluate statements more accurately, when accompanied by personal attribution however they generally help to soften claims, functioning as reader-based hedges.

There are at least four ways a writer may express the non-factual status of a proposition which Palmer (1986: 51) calls speculative, deductive, quotative and sensory. Writers can indicate they are presenting information as opinion, conclusion, report or based on the evidence of their senses, and while all epistemic devices convey this information to some extent, lexical verbs offer the most transparent means of doing so. Speculative and deductive categories involve the writer’s judgements while quotative and sensory, together with a third category concerned with the purpose of the activity, refer to the nature of supporting evidence.

### Judgemental verbs

Within this sub-set, speculative verbs indicate there is some conjecture about the truth of a proposition. It comprises mainly conventional ‘performative’ items and the tentativeness of these items allow writers to clearly distinguish the speculative and the categorical (eg 28):

(26) I suggest here that the photosynthetic apparatus in higher plants not only has to...

(27) Thus, we propose that this insert is the major site of interaction with the membrane.

(28) Although suggested, it has not been demonstrated that the isolated French bean proteases are expressed by the plant and not by the bacteroids.

Speculative verbs also include items which involve unobservable cognitive states or attitudes. These are less assured than the more ‘performative’ type.

(29) I believe that the major organisational principle of thylakoids is that of continuous unstacking and restacking of sections of the membranes ...

(30) We speculate that the inhibitor interacts specifically with a protease ....

The second type of judgements derive more obviously from inferential reasoning or calculation rather than speculation and are presented as deductions or conclusions.

(31) Of this percentage, we calculate that more than half is present in the coiled-coil portion and the rest in the globular domain.

(32) We infer that the rate becomes limited by the by the rate of regeneration of RuBP because both the calculated rate of electron transport and ..

As I observed above, a desire to hedge personal responsibility is a defining characteristic of writer-based hedges and verb choice can combine with lack of agency to obscure the operation of mental processes and encourage an interpretation of ‘leads us to the conclusion that p’ rather than ‘my interpretation is that p’.

(33) Third, the present work indicates that the aromatic ring to which the ...

(34) The model implies that the function of grana is to *shield* varying amounts.

### Evidential verbs

The second category of lexical verbs refers to evidential justification, either based on the reports of others, the writer’s senses or the purpose of discovery itself. First, scientific writers rely heavily on ‘hearsay’ evidence from the research literature and their choice of a reporting verb can indicate their commitment to what is reported. Verbs used for quotative evidence both specify and acknowledge previous findings, and also take a stance towards those findings by referring to either speculative or deductive judgements:

(35) Trifonov has suggested that the 530 loop is a component ....

(36) .. Henninger et al speculated that tuber size is correlated with extent of ....

A second group of evidential verbs refer to apprehending or sensing. In scientific writing sensory evidence is usually visual and so verbs such as ‘appear’, ‘seem’ and ‘observe’ are



commonly used to distinguish the unproven from the categorical:

(37) These changes appeared to involve both assimilatory and basic N metabolism, ...

(38) This hypothesis seems plausible because UV-B-absorbing flavonoids accumulate in leaf epidermal cells, where they may protect the ....

A third evidential sub-category hedges the means of acquiring evidence and the procedures of knowing. These contrast the purpose of the study with the results achieved and thereby allow the writer to express modesty and caution in undertaking the study itself.

(39) We sought to investigate this by studying the regulatory properties of PEPc kinase.

(40) In these FTIR studies we attempt to gain insight into the secondary structure of fibrinogen and its domains.

(41) ...we were prompted to attempt optical absorption and linear dichroism ...

Scientific writers make significantly more use of devices in the ‘speculative judgement’ category (eg ‘suggest’, ‘propose’, ‘indicate’), which seems to support Palmer’s (1986:53) suggestion that the English grammatical system permits only one type of epistemic modality. However, the categorisation is not simply a distinction between claims based on conjecture or analysis. All research statements result from careful theorising or rigorous laboratory procedures and writers are always conscious of experimental limitations, possible exceptions and alternative explanations. They recognise their results can never include every variable nor account for all aberrations, and are invariably the product of incomplete information. The choice of device is essentially strategic as writers use hedges to adjust the strength of claims and modify their confidence in their statements; they do not just distinguish judgement from evidence. These categories therefore represent the different degrees of certitude that writers confer on their claims and the fact the RAs demonstrate a clear preference for speculative over deductive judgements and of judgemental over evidential hedges suggests the adoption of pragmatically cautious positions rather than the evidence used to support them.

#### 5.2.1.3 Epistemic adjectives

20% of the hedging devices in the science corpus were adjectives with the most frequent items being ‘(un) likely’ and ‘possible’ (each 3.1 per 10,000 words), ‘most’ (2.3) and

‘consistent with’ (2.0):

(42) Together these results are consistent with the possibility, although do not prove, that the capacity to mediate the FR-HIR may be an intrinsic ...

(43) Together these data imply further that the phenotype displayed by the chromophore-deficient mutant *hy1* under FRc is likely to be due primarily to a ...

A more familiar hedge is ‘possible’, and while mainly used to express root meanings (ie. circumstances allow p), the hedging function is more common in the RAs. This ambiguity is often used to obscure the source of epistemic judgement:

(44) .... it appears possible that the mechanism causing the light activated fluorescence quenching may be triggered by either photosystem.

(45) It is also possible that phosphorylation of PEPc actually stimulates a proteolytic..

Nominalisation, by transforming an opinion into an abstract quality, achieves a similar effect:

(46) One cannot exclude a possibility that the activity of EF-2 Kinase in wheat germ ...

Many adjectival hedges are also used attributively, including about 40% of the cases of ‘possible’. This use restricts the reference of the noun while hedging the writer’s position:

(47) However, the existence of such a possible mechanism of translation regulation in plant cells was not investigated.

(48) ..the possible involvement of phytochrome C, D or E in an interactive or synergistic manner with phytochrome A cannot presently be ruled out.

Attributive uses of this kind also illustrate the prevalence of noun phrase stacking which involves packaging a complicated phenomenon into a single, syntactically complex, item by making it one element of clause structure. This allows the writer to organise concepts and content into impersonal constructions and hedge the process described in the nominal group.

(49) .. solution containing 1, 2, 3-heptanetriol,  $(\text{NH}_4)_2\text{SO}_4$  and LDAO also displayed a normal-looking B800-850 absorption spectral lineshape.

(50) ... might well be the evolutionary precursor of a probable permanent N-terminal trans membrane anchor of the microsomal enzymes.

#### 5.2.1.4 Epistemic adverbs

Adverbials are the second most common means of hedging in the journals. 36 forms were identified with the most frequent being ‘apparently’, ‘probably’ (each 2.8 per 10, 000 words), ‘essentially’, ‘relatively’ (2.4 each) and ‘generally’ (2.1).

The frequency of hedging adverbs may be due to their mobility which allows the modality of an utterance to be either ‘thematised’ (51), or to be inserted intrasententially (52):

(51) Presumably, some ‘signal’ generated in the chloroplasts initiates a ...

(52) No Pre-PS II has been detected, presumably because it has not yet been sought.

The notion of theme as “the element which serves as the point of departure of the message” (Halliday, 1985: 38) is controversial (eg Huddleston, 1988). However the choice of initial position can serve to accent the hedge and provide the reader with an alternative interpretation for the rest of the sentence, marking what follows as hypothetical and subjective.

Semantically, hedging adverbs are either ‘downtoners’ (Quirk et al, 1972: 542ff), such as ‘quite’, ‘almost’ and ‘usually’, which lower the effect of the force of the verb, and disjuncts, (eg ‘probably’, ‘generally’, ‘evidently’) that convey an attitude to the truth of a statement . ‘Downtoners’ are intensifying adjuncts which involve distinctions from ‘compromisers’ (53) through ‘diminishers’ (54), ‘minimisers’ (55) to ‘approximators’ (56).

(53) This appearance of kinase activity correlates quite well with ...

(54) This shift could be partially caused by solvent-exposed  $\alpha$  -helical segments ....

(55)..which indicate that light will rarely penetrate further than about...

(56) Eventually the PS II pool would become virtually depleted ...

These items all hedge by expressing a more precise version of the proposition, although the strongest items (approximators) almost deny the truth-value of the predicate:

(57) ...the dissociating effect of NaCl could be almost entirely suppressed, especially with respect to the 23 kDa polypeptide.

Style disjuncts (Greenbaum and Quirk, 1990:181ff) are a small class of adverbs which convey how the truth value of a proposition is perceived, and thus some serve to hedge statements:

(58) Staining was generally confined to the vascular tissues ...

(59) ... are strikingly homologous to the bovine enzyme and have a signal sequence of

approximately the same length.

Some disjuncts, approximators and adjectives are often used to hedge numerical expressions (eg Powell, 1985; Dubois, 1987). These either suggest the absence of exact measurements or simply present information accurately enough for the purpose required. A limited range of devices function in this way with the most frequent being ‘approximately’, ‘about’, ‘some’ and ‘around’ which exactly mirror Dubois’ (1987) figures for biomedical presentations.

Content disjuncts are more numerous and include a wide range of hedges relating to contingency and degrees of certainty. Again, they can qualify the status of knowledge by expressing propositions as resting on speculative, deductive, quotative and sensory evidence.

The largest group is judgemental and simply express doubt without carrying implications about the truth of the statement or the sense in which it is true or false:

(60) Oscillations in fluorescence and O<sub>2</sub> evolution activity are probably an expression..

(61) These EGTA clots are transparent and possibly comprised of..

The second group is similar to perceptual lexical verbs and conveys how the truth of the proposition can be mentally perceived. There are few examples in the corpus.

(62) ... were observed in the cytoplasm, which is apparently in contradiction to results obtained by subcellular fractionation experiments.

(63) Evidently, far-reaching structure-organising effects appear to emanate from ...

Interestingly, adverbials with -ed participle stems such as ‘allegedly’ and ‘supposedly’, which comment on reported evidence, are rare in the corpus. This is probably because the frankly sceptical view with which these items treat the reliability of reported information conflicts with academic expectations regarding the mitigation of criticism. The wide range of reporting verbs allow more subtle means of commenting on the work of others.

Hedges in the third group state the sense in which the writer judges what is said to be true and typically express a contrast with reality (64) or signify limitations on the truth (65).

(64) This can be rationalised intuitively with the favourable effect of an increased ...

(65) Our samples gave essentially the same patterns irrespective of ..

In general, hedging adverbs perform accuracy based functions and items which mitigate the force of the verb occur slightly more often than those that comment on what is said. Most downtoners have a limited modifying effect on the predicate while in the disjunct categories, judgements predominate over a concern with how truth is perceived. Overall, neutral items are the most frequent, expressing doubt without implying any sense in which this is judged or perceived.

### 5.2.2 Strategic hedges

In addition to lexical hedges, three strategies provide a significant means of scientific hedging and make up 15% of all hedges in the corpus. By referring to experimental weaknesses, limitations of the model, theory or method used, or inadequate knowledge, writers can qualify commitment by offering a measure of propositional certainty. Table 5 shows these strategies.

\*\*\*\*\* INSERT TABLE 5 HERE \*\*\*\*\*

One of the clearest ways to distinguish between conditionally true conclusions and speculative possibilities is to comment on the state of existing knowledge. While some cases help create a research space in Introductions, the majority of examples are hedges in the Results and Discussion sections. Specifying the limits of current knowledge indicates the writer is reluctant to stray far from the data, often for reasons of self protection. Some examples help ‘frame’ the proposition in a problematic environment by adjusting expectations of exactitude (66) while other cases simply signal possible alternative explanations (67):

(66) We do not know whether the increase in intensity of illumination from 250 to ...

(67) One cannot exclude a possibility that the activity of EF-2 Kinase in wheat germ is inhibited at a given stage of ontogenesis in some manner ...

Questions are a relatively common means of highlighting knowledge limitations as they can hedge the truth of a proposition by making it relative to the writer’s knowledge:

(68) Could such a putative interaction of an aminoacyl-tRDA synthesase with precursor tRNA have a physiological significance ? Although it is premature to answer this question, it might be suggested synthesase present in ...

Writers also refer to deficiencies in the research model (69), theory (70) or method (71) which may compromise the accuracy of their results. This allows the prudent researcher to anticipate challenges to the premises or methods by which results were achieved.

(69) We are aware of the concerns expressed in the literature [26] concerning the application of homology based modelling to sequences at this level of similarity.

(70) Viewed in this way the concept of lateral heterogeneity becomes obsolete ...

(71) The procedure only identifies methylated nucleotides located within the recognition sequences of the sensitive enzymes.

Conditionals are often used as they make the occurrence of one circumstance dependent on another and thereby hedge the certainty of outcomes. Hypothetical conditionals explicitly contrast the possible with the unreal (72), but most examples leave the condition open (73):

(72) These results suggest that if a flavonoid mutant with unaltered sinapate accumulation were available, it would be more sensitive to UV-B than is *tt* 4.

(73) If correct, this prediction might explain why previous exhaustive screen s have not detected mutants in phytochromes other than phytochrome B.

The most common strategy is to comment on doubts surrounding the experimental conditions, by either simply failing to guarantee the precision of experimental results with any assurance (74) or withholding endorsement of the decisiveness of claims (75):

(74) We have not been able to determine precisely whether GUS expression and Lotus leghemoglobin synthesis are initiated simultaneously, but ...

(75) So it is difficult to conclude whether the 100 kDa protein mentioned above is...

The variation of the forms used to express these strategies and the fact they are not neatly quantifiable means their significance has been overlooked in the literature. They should, however, be considered among the hedging devices available to scientific writers.

### 5.3 Distribution of devices

An interesting aspect of the distribution of hedges is their tendency to cluster, thereby reinforcing their epistemic strength. 43% of all hedges in the corpus occur in a sentence with at least one other device with 51% of all lexical verbs and 57% of all modal verbs found in

combination with other devices. The most common groupings are lexical verbs with adjectives, modal verbs with adverbials and adjectives with adverbials. ‘Suggest’, ‘would’, ‘possible’ and ‘indicate’ occur the most often in such clusters.

(76) This would probably suggest that the C-terminal processing is not achieved in the nodules, but this needs to be demonstrated.

(77) These properties indicate that SAP may play an important role in the ...

(78) ... this modification could possibly play a role in substrate binding.

The distribution of hedges in the macrostructure of RAs (Table 6) reflects their essentially rhetorical role in the discourse. The highest frequency of hedges occur in Discussion sections as it is here that authors make their claims and explore implications not directly tied to their findings. 82% of all items occur in the Research and Discussion sections with only 4% in Methods. In RAs with an IMRD organisation, Discussions averaged 36 devices per thousand words with Results and Introductions yielding 20 each.

\*\*\*\*\* INSERT TABLE 6 HERE \*\*\*\*\*

In the four part texts, 60% of epistemic modal verbs, 52% of modal nouns and 46% of adverbs are found in Discussions. While the density of items in Results sections is about a quarter of that found in Discussions, 42% of lexical verbs and 52% of references to limiting experimental conditions are found here. A breakdown is shown in Table 7.

\*\*\*\*\* INSERT TABLE 7 HERE \*\*\*\*\*

This distribution reflects the different rhetorical purposes served by the elements of textual structure, with judgements and comments predominating in the more discursive sections. The distribution varies but densities are always highest in Discussions with modal verbs (7.8 per 1,000), adverbs (7.7), lexical verbs (7.1) and adjectives (6.6) particularly prominent here. It is in Discussions that authors gain their academic credibility by going beyond the data to offer more general interpretations. The level of generality, and therefore hedging, is higher as writers can explore the ramifications of their results. In Introductions hedging largely mitigates reviews of prior research, speculates about the importance of the study and tentatively announces findings. Result sections are where new knowledge is presented and

features of experimental method discussed, requiring the writer to justify the techniques used and qualify findings. Hedges therefore preempt challenges to statements by limiting the claims made for methods and results. Finally Methods is the least obviously rhetorical section and also the least hedged, with only one tenth of the devices found in Discussions.

#### 6. Pragmatic functions and surface forms

Having sketched the pragmatic functions of hedging in this genre and described its principal forms of expression in some detail, I will now tentatively suggest how the two are related.

In science RAs hedging looks to the author, the reader and the proposition in seeking acceptance for knowledge claims and the form of hedge represents how the writer has decided to address the interactions inherent in negotiating such claims. Scientific writers always seek agreement for the strongest claims their evidence will support while also acknowledging the possibility of opposition. Hedges allow writers to upgrade or downplay their statements and thereby strengthen arguments by admitting limitations, uncertainties and the right of peers to participate in the ratification of knowledge. Writers may therefore select a hedge which seeks to present a claim with greater accuracy or with an assessment of its reliability, or one which provides some protection from the professional damage which might result from the overthrow of the claim, or a device which offers due recognition and deference to readers' views.

However, the choice of a particular device does not always permit a definite pragmatic interpretation. Writers are often seeking to achieve a number of concurrent goals and the maximally efficient exchange of information in scientific writing frequently means that particular forms convey more than one function. But while assigning particular expressions exclusively to discrete categories distorts the reality of actual usage, a fuzzy-set model allows salient features of membership to be identified while recognising that particular cases are likely to carry several meanings at once. Four contextual variables however are useful in determining core cases: specification, verification, agentivity and cooperation. Each allows readers to make certain assumptions about the writer's attitude to a proposition or its context.

A high degree of specification, or propositional precision, determines how far the terms used accurately describe the events referred to while verification acknowledges uncertainties in the truth of a claim. Both are associated with accuracy-based hedges. Agentivity entails the extent



which the writer is explicitly linked with the proposition, with non-writer agent contexts allied with core examples of content-based hedges and writer-agency related to reader-based meanings. Finally, ‘cooperative’ features, such as offering alternatives and referring to shared assumptions, seek to involve the reader in claim ratification and realise reader-based hedges. Overall, the following tentative generalisations can help identify core cases:

1. If the principal role of the device is to specify the extent which a term sufficiently describes a phenomena or the writer’s assessment of propositional truth, then it is likely to be functioning as an accuracy-based hedge.
2. If the device is used in a linguistic context which conceals the writer’s responsibility for propositional validity, then it is probably acting as a writer-based hedge.
3. If the device acknowledges the writer’s personal responsibility for propositional information or invites reader involvement, then it is likely to be a reader-based hedge.

A high degree of indeterminacy invariably characterises particular examples, but the devices most often associated with the realisation of core cases are shown in Table 8.

\*\*\*\*\* INSERT TABLE 8 HERE \*\*\*\*\*

## 7. Conclusion

Hedges are a prevalent feature of research writing in the biological sciences. This is largely because they are crucial to the procedures of argumentation and claim acceptance, playing a critical role in both the social ratification of knowledge and the system of professional rewards and recognition which emanate from publication. By identifying the purposes, distribution and major forms of hedges in science, this study has sought to increase our understanding of this important feature of scientific research writing.

Two principal features of the data are worth emphasising again. First, findings reveal the considerable variability of hedging expressions in this genre. Modal verbs have tended to receive a disproportionate amount of attention in the literature but actual usage confirms a framework of modality in which modals are only one way of indicating qualification. A second clear feature is that hedging devices are indeterminate. Devices are essentially polypragmatic and any search for a functional rationale underlying surface features must acknowledge that categorisation is a more-or-less rather than all-or nothing assessment.

Most importantly, the strategies and devices identified here are central to science as their absence is a principal means of conferring greater certainty on statements. This point is critical to students and its significance to teachers should be clear. Basic writers invariably require training in the appropriate use of hedging and foreign learners in particular find the expression of commitment and detachment to their propositions extremely troublesome. A failure to hedge statements appropriately can therefore hinder students' participation in a research world dominated by English. The RA is the key genre in academic disciplines and familiarity with its conventions, including the ability to recognise and use hedges accurately, is vital. To achieve this however, our understanding of the concept needs to be sharpened and informed by granting hedges a higher priority in both our teaching and research agendas. Only then can we begin to assist students to develop competence in this critical pragmatic area.

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Table 1: Relative frequency of hedging categories in Journal corpus

Category	Items per 1,000 words	percent	Raw number
lexical verbs	4.9	23.3	366
adverbials	4.4	21.0	329
adjectives	3.9	18.8	294
modal verbs	3.5	16.6	259
reference to limiting conditions	1.3	6.1	97
modal nouns	1.1	5.4	85
reference to a model, theory or methodology	1.1	5.3	83
admission to a lack of knowledge	0.7	3.5	55
Totals:	20.9	100	1568

Table 2: Relative frequency (%) of grammatical categories used to express hedging

Class	Journal corpus	Holmes' (1988) Corpus		Total
		Writing	Speech	
Lexical verbs	27.4	35.9	31.5	33.3
Adverbials	24.7	12.8	21.5	18.1
Adjectives	22.1	6.6	2.3	4.0
Modal verbs	19.4	36.8	42.4	40.2
Nouns	6.4	7.7	2.3	4.5



Table 3: Frequencies of modal verbs used to express hedging in different corpora  
(per 10, 000 words).

modal verb	Frequencies in various written corpora			
	Journals	Butler	JDEST	Holmes
	75, 000	32,000	25, 000	25, 000
	words	words	words	words
would (not)	10.4	6.6	16.8	18.8
may (not)	9.2	11.6	8.0	8.8
could	6.4	4.7	3.2	4.8
might (not)	3.6	2.5	2.4	4.4
should	2.4	1.2	0.8	0.8
cannot	0.8	0.3	0.0	2.0
will (not)	0.8	0.3	18.0	24.4
must	0.8	1.6	2.8	2.4
shall	0.0	0.0	0.0	0.0
ought to	0.0	0.0	0.0	0.0
Totals	34.4	29.4	52.0	66.4

Table 4: Most commonly occurring lexical verbs expressing mitigation (per 10, 000 words)

Item	Journal RAs (75, 000)	JDEST (435, 850)	Brown/LOB (J) (350, 000)
indicate	10.8	3.2	4.3
suggest	9.1	3.7	3.9
appear	4.0	2.7	3.7
propose	2.8	1.6	0.9
seem	2.3	4.0	7.7
report	1.7	2.5	2.0
predict	1.5	1.2	0.4
assume	1.1	2.3	2.9

Table 5: Most frequently occurring hedging strategies in the corpus

Category	%	number	average per RA
reference to limiting experimental conditions	41.3	97	3.7
reference to a model, theory or methodology	35.3	83	3.2
admission to a lack of knowledge	23.4	55	2.1
Totals:	100	235	9.0

Table 6: Overall distribution of hedging in various sections

	Totals	RA Section <sup>1</sup>				
		Intro	Methods	Results	Discussion	R &D <sup>2</sup>
Total words	71,635	8,989	17,904	16,791	15,770	12,181
Total Devices	1,474	180	61	336	574	323
Percentages	100	12.2	4.1	22.8	38.9	22.0
Devices per 1000 words	20.6	20.0	3.4	20.0	36.4	26.5

<sup>1</sup> Figures excluded for one RA which did not conform to the IMRD structure.

<sup>2</sup> Includes 10 RAs with combined Results and Discussion sections.

Table 7: Distribution of various devices

Epistemic Category	RA Section <sup>1</sup> (devices per 1,000 words)					Average per RA <sup>2</sup>	Raw totals
	Intro	Methods	Results	Discussion	R &D		
lexical verbs	4.9	0.6	5.7	7.1	6.2	14.1	337
adverbs	4.0	0.6	4.0	7.7	6.1	12.7	313
adjectives	3.7	1.2	4.3	6.6	4.3	11.3	285
modal verbs	2.8	0.0	2.4	7.8	3.9	9.7	237
limiting conditions	0.6	0.3	1.4	2.1	2.1	3.7	91
modal nouns	1.7	0.2	0.6	2.2	1.5	3.3	82
model, method, etc	1.0	0.4	1.2	1.8	1.1	3.2	79
lack of knowledge	1.3	0.1	0.4	1.1	1.3	2.1	53
Totals	20.0	3.4	20.0	36.4	26.5	60.1	1477

<sup>1</sup> Figures have been excluded for one RA not conforming to the IMRD structure.

<sup>2</sup> Includes all 26 articles in corpus.

Table 8: Summary of Hedging functions and principal realisation devices.

Content Motivated		Reader-Motivated
Accuracy-Based	Writer-Based	
Hedges propositional content	Hedges writer commitment	Hedges assertiveness
Epistemic Modal Verbs	Epistemic Lexical Verbs:	Epistemic Lexical Verbs:
Epistemic Adverbs:	judgemental	judgemental
content disjuncts	evidential	deductive
style disjuncts	Impersonal expressions:	Personal attribution
downtoners	passive voice	Personal reference to
Epistemic Adjectives	abstract rhetors	methods
Limited Knowledge	“empty” subjects	model
	Thematic epistemic device	Conditionals
	Attribution to literature	Involve reader
	Impersonal reference to	direct Questions
	method	reference to testability
	model	Reference to shared goals
	experimental conditions	