

AN OVERVIEW OF MODAL AUXILIARY VERBS IN E.S.T.

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When teaching the metalanguage and rhetorical patterns that are usual in English for Science Technology (EST) an instructor will certainly insist on passive verb linking words nominal group setc. which among most striking syntagmatical features. He also teach how to define or classify instance oppose contrast. not forget modal either but may consider they actually belong of EST as specific some other mentioned above.

The aim of this article is to study modal auxiliary verbs in EST, by comparing their uses with those in General Purpose English (GPE), analysing their occurrences and meanings so as to reveal similarities but, more interesting, to point out differences - if any, and to establish and interpret their functions in EST.

Part 1 - Research method

Comparing and contrasting the uses and meanings of modal verbs in EST and in general English required collecting two corpora of texts to be studied and analysed. Since the whole research work relied on the corpora, it was essential that these texts be carefully selected so as to ensure a satisfying reliability of results. (Annex 1 details the criteria for choosing the documents included in the corpora.)

Before performing a computerised count of the occurrences of modals it was however necessary to define the limits of the study and decide whether modal verbs only or modals as well as their substitutes would be taken into account. First of all, it is clear that substitutes do not express modality and cannot be classified as modal verbs. But more important, after considering the corpora in detail, it appeared that including substitutes would make little or no difference: as shown in table 3 the occurrences of 'can' or 'can' + be able', of 'may' or 'may' + be allowed' and of 'must' or 'must' + have to' are extremely parallel and the variations are hardly significant.

As a test of the reliability of these corpora, two others were gathered (one of EST with 107,310 words and one EGP one with 78,311 words) and the modal verbs were counted again. Unfortunately as it was expected, the results were different, but never exhibited a plus or minus 8% variation. This leads us to say that the figures, percentages and results that will be examined and discussed hereafter cannot be accepted too strictly and that it would be useless and perhaps dangerous to draw conclusions whenever differences are smaller than 12 / 15 %. However, the trends or the orders of magnitude that can be seen in larger

variations in percentages can be significant and therefore should be discussed even if they are not accurately quantifiable.

A second test was performed by comparing these results with those of Paul Thompson [13] who analysed PhD theses in Agricultural Botany and Agricultural Economics. Thompson's findings are based on a single genre and on a single content field, which may explain why there are certain variations between the research work and this paper, but on the whole, the results largely confirm the present ones and exhibit the same trends.

When I came to the study of each modal verb, a third problematic issue was to categorise the uses of the modal auxiliary verbs, so as to be both precise and at the same time general enough to produce manageable and meaningful results. A first way would have been to categorise the modal auxiliaries into epistemic, deontic and dynamic. But if such classification is relevant in terms of grammar it is also relatively inefficient in terms of practical communication for instance, the deontic 'may' can be used to express either a choice between two or several elements but also something optional as in the following sentences:

1/ A sensing device "*measures the required parameters: these devices **may** be gauges, photo-electric cells, thermocouples, sensors, etc.*" [a choice between several elements]

2/ "*For machining wood or brass you **may** want to install a switch cover (P/N 3015) to keep the fine dust out of the power switch.*" [something optional]

Should these two slightly different meanings be considered as one or as two categories?

In a similar way "must" can express that something is logically necessary (example 1) or it can be used to represent some kind of obligation (example 2) - not to mention the epistemic meaning of logical deduction and high degree of certainty (example 3).

1/ "*Since $2x + y = 11$ and $5y = 15$, x **must** equal 4*"

2/ "*I **must** be going now. Sam's waiting for me.*"

3/ "*The sun's already high in the sky. It **must** be almost 12*"

Would it be sensible - and perhaps feasible - to keep meanings one or two separate or to associate them?

Making out the very precise meaning of some modal verbs as well as isolating their uses in formal classes would sometimes be almost impossible and besides, would also be pointless: on the one hand the difference between 'may' expressing a choice and 'may' expressing something optional is often hardly significant and would not lead to any interesting distinction. This is why I have chosen to gather both shades of meaning under the same heading.

On the other hand, 'may' expresses possibility (example 1) but inside this larger category, it is possible to focus on more limited ones, namely hedging (example 2) and risk (example 3)

1/ "*He shouldn't be disturbed, he **may** be working.*"

2/ "*You **may** wonder how it will perform in this environment...*"

3/ "*Never remove the top cover [...] You **may** suffer serious injury if you touch these parts.*"

Just as noticed in the case of 'may' expressing choice / option, the meanings are at the same time slightly different but basically similar- as a matter of fact, 1 includes 2 and 3 - and may therefore be dealt with as either one, two or three units depending on the accuracy to be obtained.

As to 'should', I felt it necessary to keep two separate entries to refer to plain advice / recommendation from the writer to others to act and strong recommendation, almost synonymous of obligation / necessity / prohibition (must / must not), that is to say an obligation to some law, although, admittedly, the tone is not the same.

The difference appears in these sample sentences:

1/ *“Ecological optimisation of plastics types and of the range of plastics **should** also be a project field.”* [advice]

2/ *“To guarantee reliability, operating conditions **should** be kept well within maximum ratings.* “ [obligation / necessity]

But even then, it sometimes proved difficult to distribute some sentences between these categories especially when they tend to overlap: I tried to be as consistent as possible but, since this difficulty arose only in a few sentences of the corpora, it had no real impact on the results when contrasted with the total number of occurrences (respectively 199 and 153 regarding ‘should’).

Obviously, there are several types of modality, there is an infinity of shades of meaning which cannot be taken into account by rigid categories. Take these examples

1/ *“At this stage, the identification of additional needs **can** be relatively simple”*

2/ *“The first report concluded that [...] and this **would** appear to be the case from the present study”.*

In sentence 1, the writer does not suggest ability but he rather claims that his proposition / approach is legitimate. In sentence 2, ‘would’ is not a plain conditional but a hedged statement in which the writer mitigates his conclusions. But it was clearly impossible to pay attention to every little shade, all the more as, very often, the functions and meanings overlap and may be said to cohere rather than be distinguishable. On the contrary it was necessary to establish a framework in which the differences between EST and EGP could be analysed even if it was at the expense of very broad and sometimes somewhat fuzzy categories.

I have finally drawn this table showing the various meanings and entries that I have retained

modal	meaning	example	entry
can	ability /capability	He can't see us	Capability
can	choice (may)	The unit can be connected to port #1 or #2	Option
can	permission (may)	Can I open the window?	Option
can	possibility (may / perhaps)	<i>This can be done with the machine upright by letting ...</i>	Possibility
may	permission	You may come in	Option
may	choice	The mill may be mounted on a 10" x 12" or 12" x 24" pre-finished shelf board	Option
may	something optional	<i>Cutting oils and lubricants: if desired, a mixture of oil and water may be used on steel to reduce tool chatter</i>	Option
may	possibility (perhaps)	<i>The spinning mass gyro, similar to a spinning top which you may have played with as a child, ...</i>	Possibility
may	hedging	<i>Such a theory may help to improve existing methods</i>	Hedging

may	chance /risk	<i>Tools and /or parts may become distorted and accuracy will be lost.</i>	Risk
may	subjunctive	<i>Wherever you may go, you will find ...</i>	Subjunctive
must	necessity, obligation	<i>He said he must catch that train</i>	Obligation
must	high degree of certainty/ logical deduction	<i>Look at the sky. It must be cold outside</i>	High degree of certainty
will	volition / refusal	<i>He'd like to go to Canada but his parents won't let him</i>	Volition / refusal
will	future	<i>The product will be on the market by next July</i>	Future
will	prediction, logical outcome	<i>If using VB 4.0 you will need a 32 bit DLL or OCX file</i>	Prediction
would	conditional	<i>I was sure you'd be satisfied</i>	Conditional
would	past time habit	<i>She would always forget to switch off the lights</i>	Habit
would	volition / refusal	<i>I wanted to help him, but he would do it by himself</i>	Volition / refusal
shall	formal future	<i>That was a moment I shall never forget</i>	Future
shall	asking for advice or opinion	<i>Where shall we go for a drink?</i>	Asking for advice
shall	high degree of obligation (> must)	<i>The equipment shall comply with IEC 420 regulations</i>	High degree of obligation
should	advice	<i>More should be done to reduce pollution</i>	Advice
should	strong recommendation (must)	<i>Moisture-resistant coating should be applied to prevent condensation</i>	Strong recommendation
should	something expected	<i>The plastic boards should block out at least 99% of incoming light</i>	Expectation
should	emphasised improbability	<i>If the appliance should fail during the guarantee period ...</i>	hypothetical clauses
should	In hypothetical clauses with an inversion and absence of 'if'	<i>Should an electrical failure occur in the motor, the grounded plug will protect the user...</i>	hypothetical clauses
should	subjunctive	<i>It is important that the truth should be known</i>	Subjunctive
need	Absence of necessity	<i>You needn't spend so much money</i>	No entry
dare	Have enough courage to	No example found in the corpora	No entry

Table 1

I am fully aware of the shortcomings of this classification which is oversimplified, very traditional, probably obsolete and certainly inexact. Moreover it mixes several different systems of categorisation.

For instance analysing ‘would’ in terms of ‘conditional’ may be a convenient way to classify this modal verb in the paper, although there is no denying that the modal, as such, is indifferent as to condition :
“if condition is expressed, this is due to the presence of ‘if’ or some other word playing the same part” or also “the various meanings of ‘would’ come from the combination of the meanings of ‘will’ with those of ‘-ED’ (past, unreality). ‘Will’ / ‘ would’ are not endowed with semantic features such as ‘future’ or ‘condition’, which features are conveyed by the context”. (Paillard, M. *Le modal WOULD en Anglais contemporain*) quoted in Staetzel [11] (my translation)

However I felt that such an analysis of ‘would’ and of ‘will’ might not be a useful categorisation for this paper. This is why I thought it preferable to retain the traditional – though inaccurate- ‘conditional’ label and within this category to separate what really and clearly expresses prediction from hedging / tentative use.

Thus the following sentences would be classified as:

- 1/ *“And really, if you **would** allow me, I would say ... [hedging and tentative use]*
- 2/ *“ All it said was that it (= the credit card) **would** open up a new and magical world to me.” [prediction]*
- 3/ *“If the roads to city centres were freed of private commuter traffic and parked commuter cars, we **would** run far more efficient conventional public transport systems.” [conditional]*
- 4/ (In Victorian times) *“children of the ‘lower order’ **would** also work long hours.” [habit]*
- 5/ *“ So long as he lived he **would** not return to the old neighbourhood .” [volition /refusal]*

In a similar way, I have classified ‘will’ as:

- 1/ *“Your mum will have her to tea all right”, said Mr. Sunbury. “**Won't** you dear?” [volition / refusal]*
- 2/ *“Little Hayley, now 22 months, **will** never know her mum.” [plain future]*
- 3/ *“An average USA telecommuter, with young children at home, **will** gain from one-eighth (1/8) to one-sixth (1/6) of their pay when they change from full time commuting to full time telecommuting [prediction]*

In sum, comparing the uses of modals in EST and EGP with the same criteria, however inadequate they may be, is nevertheless likely to provide an interesting insight into construction of the rhetorical entities of EST and EGP.

Part 2 - Results

Overall number of modal verbs

A computerised search within the two corpora enabled me to study the number of occurrences of modals. Two tables are presented here, one excluding the substitutes of modals and the other including them.

For the sake of brevity, the following abbreviations have been used:

- * EST: science and technology corpus
- * EGP: general English corpus
- * Columns A1 and B1 : number of occurrences of each modal as well as the sum of occurrences of all the modals
- * Columns A2 and B2 show the percentage of the particular modal compared with the total number of modals (3056 and 2507)
- * Columns A3 and B3 show the occurrences of the particular modal verb per 1,000 words.

	EST			EGP		
	A1	A2	A3	B1	B2	B3
can	1226	40,1	6.1	940	37.5	4.7
will	967	31,6	4.8	429	17.1	2.1
would	257	8,4	1.3	457	18.2	2.3
may	263	8.6	1.3	286	11.4	1.4
should	199	6,4	1	153	6.1	0.8
must	134	4,4	0.7	194	7.7	1
shall	2	0,1	0	20	0,8	0,1
need not	2	0,1	0	8	0,3	0
dare	0	0	0	0	0	0
TOTAL	3056	100	15.2	2507	99.9	12.5.

Table 2 – Overall results

The first thing that can be noticed is the significantly different number of occurrences of modals in both corpora (3056 vs. 2507 or 15.2 modals per 1,000 words in the EST corpus vs. 12.5 in EGP). Even when taking into account an unavoidable statistical uncertainty due to the composition of the corpora it seems possible to say that modals are markedly more often used in EST than in EGP, the difference being approximately 20%.

It is striking to notice that EST has two predominating modals - ‘can’ and ‘will’ – which account for 72% of all occurrences while the others score modest percentages between 4 and 8%. On the other hand, in EGP the distribution is different. ‘Can’ is clearly in the lead, followed by a group of three (‘will’, ‘ would’ and ‘may’), ‘ should’ and ‘must’ having low percentages. It may also be interesting to observe that ‘will’ and ‘would’ show large divergences: 967 occurrences of will in EST and 429 in EGP. For ‘would’: 257 and 457 respectively, i.e. almost double in each case.

When considering the bottom part of table 1, it may not be a surprise to discover the very low number of occurrences of ‘shall’ and ‘need (not)’ although ‘shall’ cannot be totally neglected in the analysis of EGP. As for ‘dare’, this verb appeared in nowhere in any either corpus.

If substitutes (be able, be allowed, have to) are taken into account, the overall figures do not vary significantly as table 3 shows.

Modal	EST (occurrences)	EGP (occurrences)	Difference EST - EGP
Can (no substitutes)	1226	940	286
Can (including substitutes)	1300	1027	273

May (no substitutes)	263	286	-23
May (including substitutes)	266	296	-30
Must (no substitutes)	134	194	-60
Must (including substitutes)	306	373	-67

Table 3 - Occurrences of modals and of modals + their substitutes

Finally, we all know that mean values are simple aggregates, which can be misleading and do not reveal variations within a corpus. Thus table 5 is an example of dispersion. To compile this table, I have selected four sub-corpora within the EST one, namely extracts from technical journals, a user's manual, popularisations and reports. (The figures show the number of modals per 1,000 words)

Sub- corpus	can	may	must	will	should	TOTAL
Technical journals	6.2	1.4	0.8	6.1	1.5	16
User's manual	5.2	1	1.3	5.2	2.2	14.9
Popularisations	7.3	1.5	0.7	6.6	0.9	17
Reports	5.8	1.5	1	5.9	2.8	17
AVERAGE	6.1	1.4	1	5.9	1.9	16.2

Table 4 (1) - Dispersion

We can first notice that the average number of occurrences of modals is higher in this selection of texts (16.2 per 1,000 words) than in the whole corpus (15.2, see table 2). This may be explained by the fact that some EST genres, such as technical descriptions, medical case reports or memoranda, very rarely use any modals.

When considering the differences between genres we see that a user's manual comprises comparatively few modals (14.9 instead of 16 or 17 per 1,000 words), very probably because this genre mainly relies on verbs in the imperative as in this example:

***Avoid** touching the screen. **Do not place** your monitor near a source of water or moisture [...] **Attach** the adapter to the computer and **plug** the video cable into the adapter.*

However the relatively numerous uses of 'must' and 'should' are to be noted: this seems understandable when we remember that these verbs are used to give recommendations and instructions, which is the true purpose of a user's manual.

On the other hand, popularisations and reports are at the other end of the scale with 17 uses per 1,000 words.

When we examine each modal auxiliary, we notice very wide variations, for most of which a tentative explanation will be given in part 3:

Modal	Minimum and max occurrences per 1,000 words	Variation min / max (%)
Can	5.2 to 7.3	+ 40
May	1 to 1.5	+ 50
Must	0.7 to 1.3	+ 85
Will	5.2 to 6.6	+ 27
Should	0.9 to 2.8	+ 210

Table 4 (2) – Variations

We can now turn to a more detailed study of the uses of each modal auxiliary.

CAN

EST	occurrences	%	EGP	occurrences	%
Capability	1106	90.2	Capability	848	90.2
Possibility (may)	88	7.2	Possibility (may)	30	3.2
Option (may)	28	2.3	Option (may)	38	4
Prohibition (cannot)	4	0.3	Prohibition	0	0
TOTAL	1226	100	TOTAL	940	100

Table 5 – occurrences of ‘can’

Note : The ‘percentage’ column in this table – as in the subsequent tables - shows the percentage of occurrences of the particular meaning being examined against the total number of occurrences of the modal.

Expression of capability, possibility and option are in relatively constant proportions in both corpora while a few EST texts also use ‘can’ to express something very close to prohibition (almost a synonym of ‘must not’) as in this example: *“Maximum RPM is the highest speed recommended and cannot be exceeded without risking premature failure.”*

However the main difference to be noted is the frequency of ‘can’ in EST which is greater by 30% - whether or not one includes ‘be able to’ (1226 occurrences vs. 940 as opposed to 1300 vs. 1027 when including the substitute). This is a high percentage even when admitting a possible statistical error and it will have to be discussed. (See table 3)

Finally it should also be observed that EST readily uses ‘can’ to express possibility, which is not so common in EGP (7.2% of occurrences vs. only 3.2).

MUST

EST	occurrences	%	EGP	occurrences	%
Necessity / obligation	133	99.3	Necessity / obligation	157	80.9

High degree of certainty	1	0.7	High degree of certainty	37	19.1
TOTAL	134	100	TOTAL	194	100

Table 6 – Occurrences of ‘must’

In EST ‘must’ with 133 occurrences out of 134 exclusively means ‘it is necessary / compulsory’- or ‘prohibited’ (‘ must not’). On the contrary, in addition to this meaning (80.9%) EGP also utilises ‘must’ to express logical deduction / high degrees of certainty with 37 occurrences, i.e. 19.1%. As table 7 below shows, including ‘have to’ does not significantly alter the results.

MUST + HAVE TO

EST	occurrences	%	EGP	occurrences	%
Necessity / obligation	278	99.6	Necessity / obligation	336	90.1
High degree of necessity	1	0.4	High degree of necessity	37	9.9
TOTAL	279	100	TOTAL	373	100

Table 7 – Occurrences of ‘must’ + ‘ have to

MAY

EST	occurrences	%	EGP	occurrences	%
Possibility and hedging	223	84.8	Possibility and hedging	261	91.3
Option	40	15.2	Option	18	6.3
Subjunctive and others	0	0	Subjunctive and others	7	2.4
TOTAL	263	100	TOTAL	286	100

Table 8 – Occurrences of ‘may’

It is remarkable that there is no appreciable difference between the total number of occurrences of ‘may’ in both corpora (263 and 286). Differences, however, do appear when we scrutinise the various shades meaning: ‘may’ is not used as a subjunctive in EST (but it rarely so used in EGP). It is used 40 times to express permission, choice between two elements and option, more generally (deontic meaning). On the contrary this number falls to 18 in EGP.

Regarding the epistemic meaning of possibility - i.e. that you are not sure of the occurrence of a fact, though this is possible- we can notice an excess of 38 in favour of EGP (261 vs.223). However when examining this category, we can find a number of the sentences that clearly imply the possibility of a risk, that some unwanted event might happen: we note that 34.2% of the occurrences of ‘may’ in EST - opposed to 13.3 % in EGP- express this risk i.e. almost three times the number of occurrences in EGP (table 9). Consider this example:

“Although some photointerrupters include filters to block out visible light, certain types of light (such as sunlight and tungsten illumination, which contain wavelengths above 700nm) **may** (1) penetrate the filter and disrupt operation. Some models (such as GP2A20 and GP2A22) **may** (2) employ light modulation to counter the effects of extraneous light. Note that these models **may** (3) malfunction if exposed to extraneous illumination above 2000 lux.”

Whereas ‘may’ (2) clearly says that there is a chance to find some models using light modulation (= possibility), ‘may’ (1) and (3) go further than plain chance or possibility but suggest the idea of a risk of malfunction.

Furthermore as we will see later in the paper, ‘may’ can also be used to express hedged statements so that I have tentatively tried to classify the epistemic meaning (‘possibility’) as possibility proper, hedging and risk, knowing very well that these categories tend to overlap (table 9).

MAY expressing possibility, hedging and risk

EST	occurrences	%	EGP	occurrences	%
Possibility (proper)	101	38.4	Possibility (proper)	207	72.4
Hedging	32	12.1	Hedging	16	5.6
Risk	90	34.2	Risk	38	13.3

Table 9 – Sub-categorisation of ‘may’ expressing possibility

WILL

EST	occurrences	%	EGP	occurrences	%
Prediction	759	78.5	Prediction	277	64.6
Plain future	208	21.5	Plain future	122	28.4
Volition / refusal	0	0	Volition / refusal	36	8.4
TOTAL	967	100	TOTAL	429	100

Table 10 – occurrences of ‘will’

‘Will’ is the modal verb which seems to exhibit the most heterogeneous results. As already mentioned, it is found more than twice as often in EST as in EGP (967 vs. 429) and this will certainly require discussion.

First, it can be noticed that ‘will’ is never used in EST to express volition and refusal as in this sentence :“*I won’t do as you tell me*”(root meaning). Then, the percentages of plain future and prediction (epistemic meaning) seem to be fairly consistent between the two corpora. However a detailed study of the ‘prediction’ entry reveals further differences.

It is necessary to introduce here the notion of timeless, habitual and specific prediction: in a prediction, the speaker starts from what he knows about the given situation, and basing his reflection upon this knowledge, he infers what the consequences are likely to be.

“Oil **will** float on water” or “boys **will** be boys” are the favourite examples of grammar books. Considering all the speaker knows about the law of gravity, the density of water and of oil, etc. he can predict that if he pours oil on water, the former will float on the latter. Similarly his experience of boys, of their psychology and their behaviour prompts him to predict that a boy, any boy, is sure to react exactly like others in a given situation.

Now predictions can be made irrespective of time as in the examples above (they are called timeless predictions) “A few drops of light oil behind the handwheel **will** reduce friction between the surfaces” or “Thermal protection means there is a built-in circuit breaker that **will** shut down the motor if it gets too hot.”

Predictions can also be habitual ones (“He **will** talk for hours if you give him the chance.”) or can also be specific: in this case they are often expressed by means of ‘if’, ‘when’ or ‘as soon as’, etc. as in these examples: “Motor size for a given job **will** be smaller if you can use a higher RPM” or also “When this is not possible, it (= the software) **will** generate straight geometry and **will** flag this in the conversion report.”

When keeping the three classes of predictions in mind, we can sort the occurrences of the predictive ‘will’ as follows:

WILL expressing prediction

EST	occurrences	%	EGP	occurrences	%
Timeless prediction	26	3.4	Timeless prediction	2	0.8
Habitual prediction	1	0.1	Habitual prediction	19	6.9
Specific prediction	733	96.6	Specific prediction	256	92.4

Table 11 – Sub-categorisation of ‘will’ expressing prediction

It may be interesting to observe that timeless prediction are found almost exclusively in EST while, conversely, habitual predictions do not seem to belong to this field.

WOULD

‘Would’ is the modal verb I have found most difficult to categorise: it is clear that the term “plain conditional” is inadequate to describe its modal uses (prediction, usually called ‘future in the past’, polite requests / tentative uses and modal preterit). Strictly speaking, it might be named ‘conditional’ only in the case of hypothetical sentences. For the sake of clarity and simplicity, I have tentatively tried to categorise the so-called ‘conditional’ as ‘prediction’ and ‘hedging’ whenever these meaning were obvious or likely, the rest being labelled ‘conditional. (See table 13). Past time habits / repetition (although it not ‘would’ that expresses the concept but the context) and volition (root meaning) are easier to classify.

WOULD

EST	occurrences	%	EGP	occurrences	%

Conditional	247	96.1	Conditional	416	91
Volition / refusal	8	3.1	Volition / refusal	22	4.8
Habit	2	0.8	Habit	19	4.2
TOTAL	257	100	TOTAL	457	100

Table 12 – Occurrences of ‘would’

Let us now examine the results. First, the most striking figure is the number of occurrences of ‘would’ in EST and EGP with a difference of 70% in favour of EGP. Second, as expected, the notions of volition and habit are rare in EST - science and technology are certainly not used to dealing with these.

Table 13 categorises the so-called ‘conditional’ and, as in the case of ‘will’, exhibits a notably higher proportion of occurrences of predictions in EST while the percentages relating to hedging are very similar in both corpora..

‘CONDITIONAL’ WOULD

EST	occurrences	%	EGP	occurrences	%
Conditional	122	47.5	Conditional	252	55.2
Prediction	101	39.3	Prediction	116	25.4
Hedging	24	9.3	Hedging	48	10.5

Table 13 – Sub-categorisation of conditional ‘would’

SHALL

EST	occurrences	%	EGP	occurrences	%
Future	1	33.3	Future	14	70
High degree of obligation	2	66.7	High degree of obligation	5	25
Asking for advice	0	0	Asking for advice	1	5
TOTAL	3	100	TOTAL	20	100

Table 14 – Occurrences of ‘shall’

In addition to an occurrence of ‘shall’ that was clearly a future, there were only two other occurrences in the EST corpus, such as “*The company shall not be liable for any direct consequential or incidental loss or damage...*” They express legal obligations so that they can hardly be recorded as a feature of EST.

SHOULD

EST	occurrences	%	EGP	occurrences	%
advice	9	4.5	advice	57	37.3
Strong recommendation	101	50.8	Strong recommendation	63	41.2
Expectation	85	42.7	Expectation	18	11.8
Hypothetical clauses	3	1.5	Hypothetical clauses	10	6.5
Subjunctive	1	0.5	Subjunctive	5	3.3
TOTAL	199	100	TOTAL	153	100.1

Table 15 – occurrences of ‘should’

It is easy to see that ‘should’ is used differently in EST and EGP.

First, the total number of occurrences varies by approximately 25%, in favour of EST, a figure which, even when bearing statistical uncertainty in mind, is remarkable.

Then, let us quickly examine the less common uses (viz. emphasised improbability; inversion and absence of ‘if’ in hypothetical clauses; subjunctive) to notice that, as probably expected, these formal or literary uses are exceptional - but present- in EST, while they are far from infrequent in EGP (9.8 % of occurrences altogether).

In reference to ‘should’ expressing advice, we can notice an important difference: it is hardly used in EST (4.5%) by contrast with EGP (37.3%). Though not so large, a similar discrepancy can be found to express strong recommendation (something akin to an obligation or necessity and which might have been expressed by means of ‘must’) 50.8% vs. 41.2%. Here is an example:

*“Light-shielding boards for transmissive photointerrupters **should** (1) be metal or plastic. If carefully fitted, plastic boards **should** (2) block out at least 99% of incoming light.”*

We can notice that, as in many other cases, the same modal can be used with different meanings within the same paragraph: ‘should’ (1) is a strong recommendation as discussed here, while ‘should’ (2) suggests the expected result of employing plastic boards.

Among the 101 occurrences expressing strong recommendation, table 16 further shows that ‘should not’ expresses something very close to prohibition in 6 cases (a user’s manual, as a matter of fact), which seems never to happen in EGP. An example of such meaning can be: “ *Environment humidity should never exceed 60%.*”

Should not / never to express prohibition

EST	occurrences	%	EGP	occurrences	%
prohibition	6	3	prohibition	0	0

Table 16 – ‘Should not’ expressing prohibition

Regarding the expression of expected result or consequence , ‘should’ is used 85 times in EST (42.7%) and only 18 times in EGP (11.8%) , a large difference which might be explained only by the very nature of scientific and technological communication.

MODALS and NATIVE vs. NON-NATIVE SPEAKERS

Although it is often difficult to know whether a document has been written by NSE (native speakers of English font-family) or by NNSE (non-native speakers of English) since authors' names can be misleading and besides a text written by a NNSE may have been revised by a native speaker, I thought it interesting to study the uses of modal auxiliaries with relation to the author's L1.

Several parallel texts have been compared, namely two research articles in Mathematics about the same subject (one written by an American, the other by two Frenchmen) and four short announcements for scientific meetings. (A British and an American writer; two German ones). The German papers had clearly not been revised by NSE as they displayed several 'grammar mistakes' such as "*Electrical drives are known in automobiles since the very beginning of building cars*" and "*the [...] development took evidently place in microelectronics*".

Corpus : 5162 words	NATIVE	SPEAKER	Corpus : 5776 words	NON- NATIVE	SPEAKER
	Number of occurrences	Per 1,000 words (%)		Number of occurrences	Per 1,000 words (%)
Can	22	4.3	Can	20	3.5
Will	13	2.5	Will	14	2.4
Would	5	1	Would	5	0.9
May	17	3.3	May	4	0.7
Should	6	1.2	Should	3	0.5
Must	6	1.2	Must	5	0.9
TOTAL	69	13.5	TOTAL	51	8.9

Table 17 - Occurrences of modals verbs in native and non-native speakers' writing

Of course, the sub-corpora are too small to allow us to draw precise quantitative conclusions however the trends are undoubtedly clear: the total occurrences of modal verbs in the NSE documents do compare with the overall results shown in table 2 (15.2 modals per 1,000 words) and the table above indicates such large variations between in the use of modal verbs in the case of NSE and NNSE (13.5 modals vs. 8.9 per 1,000 words) that they cannot be disregarded.

In addition to this, another striking difference between the two corpora is probably the use of 'may' with 3.3 occurrences per 1,000 words in native speakers' articles – by the way, a figure much higher than the mere 1.3 in the whole EST corpus - while 'may' is hardly ever used in the NNSE papers.

The paper will first analyse and discuss some functions and features of scientific and technical writing with reference to the use of modals, including attitudinal markers and author's comments usually referred to as hedges. It will then re-examine several of the results obtained in part 2 in the light of the new data.

The primary focus of most scientific and technical thinking and writing is solving a problem or problems. This is why scientific and technical literature is mainly concerned with:

- A/ Presenting facts and data;
- B/ Interpreting the data;
- C/ Assessing the arguments and results;
- D/ Drawing conclusions and reaching a synthesis;
- E/ Giving instructions;
- F/ Guiding the reader;

In addition,

- G/ Hedging appears to be a constant feature of EST;
- H/ Native and non-native speakers make different uses of modals.

Note: I am greatly indebted to Mike McGrath's Taxonomy [8] and to Paul Thompson's Academic writers putting modal verbs to work [13] for the following categorisation.

Scientific and technical English is not homogeneous and each the above functions has its own specific characteristics within which we are likely to discover various proportions of modal verbs as well as an over- or under-exemplification of some of them.

A/ Presenting facts and data .

Presenting facts and data, describing phenomena is an objective, informative part of discourse which is not likely to be disputed - opposed to an interpretative part as studied below. This may explain why the average frequency of modal verbs is slightly lower in reports than in the rest of EST (See table 4(1).)

Presenting facts and data comprises many different categories and communicative purposes all of them not being likely to require a notable use of modals. However, among those which do require it, there may be various modals, but especially 'can' and 'will', used to describe properties and procedures (such as below).

Stating laws and principles:

This is often expressed by means of 'will' or 'would' (at a hypothetical level).

*"Electricity **will** only flow when a power source, such as a battery or a generator, sets the electrons in motion and when the electrons can complete a full circle."*

Describing properties and procedures

*"In a fibre-optic gyro (FOG), in order to determine the rate of rotation, the output from a light source is split into two beams which simultaneously traverse a circular path in opposite directions. If the FOG is not rotating, then both beams **will** traverse exactly the same distance and, when re-combined, they **will** be exactly in phase and will give maximum intensity at an optical detector. If the FOG is rotating, [...]when the beams are recombined, they **will** no longer be in phase and the*

*relative phase shift **can** be detected as a decrease in intensity at the detector.”*

This is the kind of declarative statement that is the most common in technical journals and popularisations.

Stating use and function:

It will seem obvious to find a large number of occurrences of ‘can’, particularly in phrases such as: can be used, can be operated, can allow, can provide, etc.

The new fire detector “**can** pick up reflections from a fire off the walls, so it **can** directly survey a multiple-room enclosure for fire from a single location.”

“The NR 107 modem **can** also be used as an answering device thanks to the 4 buttons on the front panel.”

Expressing ability:

This is usually done using ‘can’ or ‘could’; to indicate various degrees of possibility, the phrase ‘be able to’ is also quite usual, combining with should, may or will. However, ‘may’ is also sometimes used as in this example:

“The principle of the conservation of energy states that energy **can** neither be created nor destroyed nor **may** be converted from one form into another”.

It can be noticed that the predominating modals in this section are ‘can’ (dynamic modal which ascribes the property of ability to the subject of the sentence) and will’(epistemic meaning) that is to say verbs that are used to establish what is known about the subject and not to express any form of uncertainty, doubt or hesitation.

B/ Interpreting the data

After describing phenomena, we now turn to the process of scientific investigation

Describing procedural correctness:

The use of modals of obligation and necessity is particularly usual in science, mathematics and engineering textbooks in order to describe procedural correctness as for instance:

“The above equation may also be applied to brakes, clutches, and other applications employing frictional torque. It **must** be remembered that n is the speed of rotation in RPM, R is the friction force in newtons ...”

However other verbs can be found, such as ‘can and ‘may’:

“When an object is viewed through another medium, a virtual image appears [...] It **can** be shown that the apparent displacement of d is given by the formula ...” Obviously, this sentence does not express ability, but the writer says that his claim is correct and legitimate.

Identifying and stating causes and effects:

A scientist’s or technician’s important task is to examine the consequences of a claim or action. The choice of the modal to be used is bound to depend on the predictability of the effect (from low possibility to established certainty) .

“However, when the gas turbine is mechanically disconnected from the workload, it **will** increase

speed momentarily, which **may** also damage the turbine. Appell (managing director of Voith Safeset AB in Sweden) says that the best point to limit overspeeding **would** be between the gas turbine, which has relatively low inertia, and the generator, which has relatively high inertia .”

Suggesting the possibility / feasibility of the arguments / procedures that are being developed.

“Industry experts said that millions of pounds **could** be saved annually by removing the need to make copies of new releases for world audiences.”

“To guarantee reliability, operating conditions **should** be kept well within maximum ratings. In practice, actual maximum ratings **should** be lowered ("derated") to provide an extra margin of safety, as follows :”

In the above instances, the writer, who knows that the responsibility for the claim lies with him, expresses tentativeness with ‘could’, ‘ should’ (or ‘might’ or ‘would) i.e. with the so-called ‘conditional’ forms of modals but in other cases he might prefer to be more assertive and use predictive statements:

“With a change in architecture software development methodology and the implantation of known technology, the cost **can** be cut more than 50% [...] Also using analog circuitry for feedback **will** provide a real time solution...”

Considering alternatives:

One of the meanings of ‘may’ is to express either a choice between two or several elements or something optional so that it is naturally found when proposing alternatives.

“Depending upon the style they (= resistors) **may** be encapsulated in lacquer, high temperature cement or by moulding.”

However other modal auxiliaries can also be used depending on the writer’s strategy, for instance when expressing alternatives that are still hypothetical:

“C&IG has established a system to review each project throughout its major development phases and consider whether it **could** be continued, or whether it **should** be delayed, or even canceled.”

Discussing possible actions, outcomes or types of results:

“Ideally, compounds **would** be tested on all the principal pets but unfortunately some are impossible to breed [...] because the establishment of a breeding colony **might** entail a risk of spreading a species which is still unknown in Europe.”

“In accordance with this principle, there **would** thus appear to be some connection between heat and mechanical energy, and the law of thermodynamics is concerned with this connection.”

In the last example, the conditional can be considered as a typical form of hedged prediction when the outcome is still hypothetical and requires further research, but predictive ‘will’ can also be present depending on the writer’s opinion or degree of involvement.

C/ Assessing the arguments and results.

Comparing and contrasting:

When comparing and contrasting in order to show the difference between two actions, procedures or

arguments, most of the auxiliary verbs can be used depending on the author's strategy, as for instance:

*“The thermal efficiency of a heat engine **may** be of the order of 15 per cent to 30 per cent. [...] Some of the heat produced by the combustion of the fuel **will** be wasted in radiation, cooling water, exhaust gases, windage and friction, etc. The process of converting mechanical [...] energy into heat is not accompanied by such an excessive waste; e.g. an electric heater **can have** an efficiency of about 80 per cent to 90 per cent.”*

Drawing attention to the effects of change:

As the example below shows, expressing risk and prediction (or expected outcome with 'should') is a usual feature.

*“However, when the gas turbine is mechanically disconnected from the workload, it **will** increase speed momentarily, which **may** also damage the turbine.”*

Expressing conditions:

*“If the Martian climate became more hospitable [...] a chain reaction **could** start [...] Mars **might** be suitable for plants.”*

We have previously mentioned the fairly rare substitution of 'should' + inversion for 'if' to express hypothesis. One example is:

*“**Should** an oil leak develop, the seal should be replaced as shown in Fig. 3.”*

Making predictions:

Drawing on natural or scientific laws and / or previous information, the writer states that what he is talking about is very likely to happen ('will') or may happen ('would').

*“The ongoing research into these early interactions **will** undoubtedly lead one day to important new insights into cellular interaction.”*

Or also:

(About implants in defective bones) he *“is hopeful that continuing research **will** someday boost mechanical properties up to the middle of the range, which **would** open up all sorts of bone replacement applications.”*

D/ Drawing conclusions and reaching a synthesis

Recommending or expressing necessity given the circumstances.

*If a vacuum **must** be maintained in the system when the pump is stopped, an isolation valve **should** be fitted in the pumping line .”*

It should be noted that the distinction between necessity / obligation and recommendation is often theoretical as here, where 'should' is used to express such a high degree of recommendation that it actually comes to mean necessity.

Concluding :

Whenever more or less tentative generalisations are made 'may', ' would' or 'will' are frequently used.

“Without VSA-3D, Hewlett-Packard engineers **would** not have had an objective way to compare different designs and reach the conclusion they did. They **would** have kept going with the more complex service station design until prototypes revealed problems.”

Or also

“Although such thoughts are speculative, they **may** lead to the profoundest scientific contributions of the work on OCD.”

E/ Giving instructions :

This is a specific domain of technical literature, that of operation manuals or guides enabling the user to install, use and maintain the appliance or system. In addition to verbs in the imperative, such literature, as might be expected, makes mainly use of modal verbs expressing advice, recommendation and obligation (or prohibition):

“ *This pump can be used as a compressor to deliver air at pressures up to 10 p.s.i. Care **must** be taken to ensure that the pressure relief valve provided is never completely closed [...] If the pump is cold, the pump oil **should** be warmed before pumping vapours so as to prevent vapour condensation. [...] If a vacuum **must** be maintained in the system when the pump is stopped, an isolation valve **should** be fitted in the pumping line. [...]*”

In addition, the user is often warned of possible risks as in this sentence:

“*Turn the button to OFF [...] failure to do so **may** cause the battery to lose its charge.*”

F/ Guiding the reader

It is sometimes necessary to guide readers through the document particularly if it is very long (articles, dissertations, reports, theses, etc.) or complex, for instance in the discussion section of a research article, that represents the author’s involvement when presenting arguments and results or expressing recommendations. In particular, the author's presence can be particularly considerable when he wants to guide readers by underlining the important items and drawing attention to them. This may be done without resorting to modal verbs (for instance: “as previously shown in part X”), but very often with such phrases as “as **will** be explained / shown later” or “it **should** be noted that...”

Consider this common way of starting a paper:

*In this article we **will** review the work in [21] that aimed at providing a general framework as well as a stability and accuracy for these numerical methods. For convenience and to emphasize the multi-physics nature of these methods, we **will** call them Heterogeneous Multiscale Methods.*”

The author announces the plan that he will use, first a survey of previous work before proceeding to the main part of the paper, and he also defines the vocabulary that he will employ (“ *we **will** call them...*”) Thus the reader is provided with guidelines which are meant to act as sign posts and help direct him through the document.

Sign posting can also be achieved using conventionalised phrases such as ‘as can be seen’, ‘ as expected’, or ‘it should be noted’, ‘ note should be taken that ...’ in order to introduce remarks and notes in a less affirmative way than a verb in the imperative.

It is indeed important that the reader should be placed in a linguistic environment that he is cognisant of in

order to be able to participate in communication in specialised genres and fields.

G/ Hedging

It is true that hedges seem to be in line with the cultural preference of at least British English for understatement and this is likely to have had an influence on EGP but .regarding EST, hedging may be a way for a writer to express his reactions in front of the claims that he presents. Indeed, it is a strategy to avoid absolute categorical statements and to signal distance (either because the writer expects opposition to his claims and therefore wishes to diminish his exposure to criticism or refuses to express his commitment categorically or simply does not wish to sound boastful) .

For instance, Wood [14] quotes this famous remark by the 1962 medicine Nobel Prize winners, Watson and Crick: "*It has not escaped our notice that the specific pairing we have postulated immediately suggests a possible copying mechanism for the genetic material.*"

Given the heterogeneity of genres in scientific and technical writing, it is difficult to evaluate the importance of hedging in general, as a paper which presents the latest trends in research and evaluates future paths, is likely to use hedging much more than the narrative of a popularisation or the procedures and instructions of a user's manual which are more objective and informative. Hedged statements are particularly present every time one tries to deconstruct a theory in the light of previous contrary evidence. For instance: "*If these results are accurate it **might** mean the older gravimetric determinations have overlooked the tendency to accompany rare earths in the oxalate precipitate.*" Hedging is also commonly found when reaching a synthesis or defending a point of view:" *These results suggest that benign migratory glossitis **may** be linked to diabetes mellitus.*"

It is important to realise that hedging is not solely expressed by means of modal verbs: a speaker / writer can use other tools such as:

Adverbials: probably, (un)likely, hardly, slightly, etc.

Verbs: seem, appear, indicate, assume, suggest (as in the example above), etc.

Nouns: assumption, suggestion, possibility, etc.

Adjectives: (im)possible, surprising, likely, estimated, etc.

A writer can also make his claim into a hypothetical sentence as the example above (*If these results are accurate it **might** mean ...*)

However, English has a highly developed modality system which makes it relatively easy to express hedged statements. These verbs are first of all: may / might, can / could, should and would i.e. epistemic modals which express a judgement about the truth of the proposition.

'May' expresses possibility but we have seen that it can express risk (a sub-category of possibility). Both meanings can easily be used for hedging as in these examples:

1/ "*You **may** wonder how it will perform in an environment that **may** be very difficult.*"

2/ "*Global warming would result in profound shifts in agriculture and **may**, as some have suggested, hasten the spread of infectious diseases*".

'Would' (as a conditional) can be felt as a hypothetical or weaker form of 'will' to express a prediction which has not got the definite certainty of 'will'. As a matter of fact, 'would' is a median positive modal which is less tentative when compared to 'may' but also less affirmative than 'will'.

*"They conclude that the platform **would** enhance the effectiveness of object-oriented development*

as well as the reuse of control-technology hardware and software, in which Java byte code played a pivotal role.” This is clearly more positive than “they conclude that the platform **may** enhance the effectiveness...” though less straightforward than “they conclude that the platform **will** enhance the effectiveness...”

Furthermore, ‘should’ can express an expected outcome (as in “ A number of new technology advances are within reach which **should** vastly lower the cost of utilizing space during the next 10-20 years “) and can therefore sometimes be used to as a hedged form to express certainty or necessity (instead of ‘must’) or prediction (instead of ‘will’):

“This integration **should** significantly reduce the number of telephone calls to our service centers.” (In lieu of ‘will reduce’)

As will be suggested later, this may have a connection with the number of occurrences of ‘should’ in reports.

H/ Native and non-native speakers make different uses of modals.

Wood [14] argues that NNSE tend to use fewer modal verbs than native ones - perhaps because their L1 does not possess such a verbal system so that they either do not express modality at all or they resort to other methods to express it. Wood writes:

“I have frequently found [...] that their conclusions are presented in the following kind of more forthright style: "These results prove that...". This is very often quite acceptable in the native language of the speaker but in English the preferred style would be something more like "These results would seem to indicate that ...".

The results displayed in table 17 seem to corroborate Wood’s findings, with only 8.9 modal verbs per 1,000 words instead of 13.5 in a similar Anglo-Saxon sub-corpus.

Several remarks can be made:

a/ In NNS writing; most of the time ‘will’ and ‘would’ are used to express plain future and conditional and the notion of prediction is hardly present : (*in this seminar*) ‘it will be shown ...some future applications will be discussed...’ Will’ and ‘would’ are clearly felt as future and conditional tenses and hardly as means to express any form of modality.

b/ This is even more obvious with ‘may’. It is interesting to see the limited use of this modal in the French document (2 occurrences) as opposed to 14 in its American counterpart. This may be explained by the fact that the epistemic meaning (possibility) corresponds to no specific French verb so that the writer uses literal translations of French phrases in order to express possibility (i.e. ‘perhaps or ‘maybe’’). Consider this example:

“Note that, due to the mixed boundary conditions, we will **perhaps** not be able to get ‘regular’ solutions...” whereas a native speaker would have been likely to write :” we **may / might** not be able...”

We can now turn to a re-examination of several of the results obtained in Part 2. We will discuss:

- * the overall number of occurrences of modal verbs in EST and EGP;
- * the discrepancy in the number of uses of ‘can’ in both corpora;
- * the disconnection between the uses of ‘will’ and those of ‘would’ in EST and EGP;

- * the absence of ‘must’ to express logical deduction in EST;
- * the case of ‘may’, to express option and choice or to express risk;
- * the use of ‘should’ for recommendations and expected results.

Overall number of occurrences of modal verbs in EST and EGP

The analysis as performed in Part 2 (table 2) confirms that each variety of English has different features regarding modal verbs with about 20% more occurrences in EST than in EGP.

One of the functions of scientific and technical communication is to describe properties and procedures, state laws and principles, state use and function and express ability, that is to say to establish what is already known or commonly accepted about the subject. This, as we have seen, is often expressed with modal verbs, especially ‘can’ (subject-oriented). Secondly, scientific and technical communication is also epistemically-oriented with the speaker expressing various degrees of commitment / responsibility for the validity of a statement or for the attitude expressed. Obviously, this is the right place for modal auxiliaries and we have seen that almost all of them are commonly used for this purpose.

In brief, the higher number of modal verb occurrences may seem understandable in the light of the nature of EST.

Discrepancy in the number of uses of ‘can’ in both corpora

We can understand the difference in use of ‘can’ (1226 occurrences vs. 940) by the importance given to literature review, factual evidence descriptions and explanations of procedures, information about what can or cannot be performed. This is particularly obvious in technical journals and even more in popularisations, with over 7 occurrences of ‘can’ every 1,000 words. These articles are mainly a reformulation activity - often a discourse about another one, a subject-oriented one in which the writer is not personally involved.

It may be worth noting the use of ‘can’ to express possibility. While this is a fairly common sense in EST, it is much rarer in EGP, which seems to prefer ‘may’. (See tables 5 and 8.) For instance in this sentence ‘can’ (2) expresses potential risk, just as ‘may’ could do:

*“Detecting collisions **can** (1) prevent serious damage to the workpiece, tool and machine. Broken tools, if not detected, **can** (2) lead to collisions. Tool monitoring **can** (3) detect broken tools immediately and minimise damage.”* As previously noted, the same modal is used with different meanings, expressing ability in (1), risk - a sub category of 'possibility' - in (2) and ability again (3).

Disconnection between the uses of ‘will’ and ‘would’

We can now turn to ‘will’ and the first point to be accounted for is the number of occurrences in EST (967) as opposed to EGP (429).

We have seen that ‘will’ can be used when presenting facts and data, interpreting them and especially assessing the arguments and results. All these operations are also performed in general communication but this is only one kind of operation among others while predicting is one of the most unexceptional activities of scientific and technological communication since predictions are intended to be used as a basis for action.

In specific contexts such as progress reports, it is even possible to find extremely large number of occurrences of ‘will’ in a few lines, sometimes as many as 50 per 1,000 words – or even more as in this example of a

progress report about an Information Management System for Texas Department of Housing (59 ‘will’ per 1,000 words):

“System Functionality. *The functional requirements of the database include what the database **will** do and how it **will** be used.*

Work completed. *The general functional specifications for the project have been identified. The database **will** be created as a data warehouse. The data **will** be drawn from existing database systems in the agency through the use of interfaces. There **will** be no live data entry into the system. The data **will** be imported into the new data warehouse on a monthly basis. The frequency of data transfer **will** be increased after the initial system test.*

Work remaining . *The functions of the project have been expanded. Executive management would like for the database to be accessible on the web. A web interface **will** be developed to allow users to access the data according to their specific needs .”*

A more detailed study of the predictive ‘will’ has revealed the relative importance of timeless predictions in EST (very rare in EGP), mainly to state laws and principles, as in this extract from a science course book:

*“For an angular velocity i.e. no acceleration, the graph is a horizontal line having no zero gradient. The graph of uniformly retarded motion **will** show a constant negative gradient .”*

Regarding specific predictions (the majority of cases, 733 out of 767 uses of ‘will’), it is clear that this is a very common notion in English generally speaking, but notably in EST where it is customary to discuss what happens - or rather what will happen - when or if a given action / procedure / operation is performed, as it is particularly the case in progress reports. (In the one mentioned above, we have counted 50 occurrences of the predictive ‘will’ in 2,730 words, i.e. 18 per 1,000 words)

Unlike the other modals, ‘would’ is definitely rarer in EST than in EGP. This may come as a surprise but do not forget that interview situations, memories and reminiscences about the past and about how life used to be are not so infrequent in magazines and novels – and this is the very function of ‘would’. Moreover, ‘would’ is also used to express volition (and refusal), a notion which is rarely expressed in EST.

On the other hand, ‘would’ is far from absent from EST, particularly to discuss possible actions and outcomes and to express tentative and hedged predictions.

However all this is insufficient to understand the large placer of ‘would’ in EGP and further research is suggested to try and explain it.

Absence of ‘must’ to express logical deduction

Regarding ‘must’ we have noticed that EST hardly ever uses it to express the epistemic logical deduction / high degree of necessity (only 1 occurrence, see table 6). As a matter of fact, logical deduction means that, given all that I know about the initial situation, I can logically deduce one or several consequences. This concept is very close to prediction and expectation. If you say “Mum’s not here, she must be in the kitchen” or “Mum’s not here, she will / should be in the kitchen” it is true that you do not exactly mean the same thing: you are more assertive in the first sentence than in the second, but in both cases, deduction or prediction fundamentally rely on the same kind of intellectual process. You start from what you know about your mother’s activities and habits, from what noises you can hear coming from the kitchen and from the available and direct evidence and the conclusion is very similar : there are very good chances to find her in the kitchen. In EST, this would very likely be expressed with ‘will’ or ‘should’. Consider this example:

“For variable speed motion control to have mass acceptance, the cost must be cut in half. [...]

*Integrated ASICs can be developed for specific applications that reduce time and cost [...] Also, using analog circuitry for feedback and filtering system will provide a real time solution. [...] These improvements in control system performance **will** allow the use of a less expensive motor, the number one cost element in a motion control system.”* Whether the writer expressed prediction (‘will’), an expected result (‘should’) or deduction (‘must’), the reasoning process remains the same: the author of the article analyses the causes of the problems concerning motion control systems and, taking several possible technological solutions into account, he can figure out, deduce, expect or predict a new control architecture that would solve or ease the problem.

All this does not explain why EST never uses the logical deduction meaning of ‘must’, at any rate it may show how the notion is expressed in EST.

‘May’, to express option and choice or to express risk

There seems to be little to discuss about ‘may’ since - as seen previously- the occurrences of this modal are apparently similar in EST and EGP. There is certainly no need to dwell on the subjunctive use - all the more so as grammarians would criticise this term.

Second, the paper has also dealt with the issue of hedging and writers often use the modal 'may' to talk about their own research, particularly when presenting the research method or in the discussion section of papers (Up to 50% of all the occurrences of ‘may’ in a paper can be found in this section and most of the time to indicate tentative statements.)

More interesting when comparing EST and EGP, the ‘option’ meaning , which comprises the notions of permission, choice and option proper, is distinctly more common in EST (15.2 occurrences per 1,000 words opposed to 6.3).

Permission is not really a major concern of scientific and technological communication, but choice and option are: it is common for any scientist, engineer or technician to be confronted with several theories, several possible techniques or several solutions or to have optional moves that they can decide to pursue or not as in these examples:

1/ *“With SolidWorks e-Drawing Professional version, users **may** choose to disable the measurement feature so others can’t determine exact specifications, dynamic component translation, or cross-section views of the e-Drawing.”*

2/ *“Much can be written about the use of lubricants, but they **may** usually be dispensed with where production rates are not very important. A small amount of any kind of oil applied with a small brush will be sufficient. [...] If desired, a mixture of one part soluble oil to six parts water **may** be used on steel to assist in producing a smoother finish and reduce tool chatter when parting off. Brass and cast iron are always turned dry.”*

However one of the most remarkable differences between EST and EGP is the expression of the notion of potential risk in EST. It seems obvious that talking about risks, chances, hazards and dangers, analysing their chances of occurring, cautioning against them is one of the purposes of scientific and technological communication and this probably explains why over a third of the uses of ‘may’ (as opposed to 13.4% in EGP) concerns the expression of risks. (See table 9 for figures and examples.) To talk about a more moderate or attenuated risk, the author can use ‘might’ :

*“This method has, however, two drawbacks: it increases Refiom weight and size and the heavy metals in the Refiom **might** leak into the surrounding environment.”*

It should be observed that ‘ can’ (and ‘could’) can be used to express the same concept:

“ This is very important because if the torque is too high, the bottles **can** be broken or crushed. ”

Use of ‘should’ for recommendations and expected results

Table 15 clearly shows that the deontic ‘should’ in EST is predominantly used to express strong recommendation, not advice, contrary to EGP. The communicative purpose of EST is rarely to give advice and to influence other people but to state clear indications, to give recommendations that are so definite and substantial that they almost amount to expressing obligation and necessity. Similarly, we have seen that ‘should not’ can be used to express something very similar to prohibition, just like ‘must not’ - which does not seem ever to happen in EGP (table 16.)

*(“When it is necessary for materials to be fed through the guard during the work process, openings should be sufficient only to allow the passage of these materials, but **should not** create a trap between the material and the guard. **Under no circumstances should** there be openings of a dimension large enough between the material and the guard to allow a person access into the safeguarded area.”)*

Table 13 shows us that 42% of the occurrences of ‘should’ express expectation. We have previously seen that one of the important roles of research – whether theoretical or applied – is to make predictions and consequently to suggest, present and discuss expected results or consequences.

Indeed, whenever experiments and tests have been conducted, it is possible to infer either definite conclusions (expressed by ‘will’ or ‘must’) or at least probable deductions which obviously can be best expressed using ‘should’ as in *”What is clear is that a number of new technology advances are within reach which **should** vastly lower the cost of utilizing space during the next 10-20 years”* or also *:”these improvements in control systems performance **should** allow the use of a less expensive motor, the number one cost element in a motion control system.”*

Thus we can now understand the exceptionally high number of occurrences of ‘should’ in reports (2.8 per 1,000 words, see table 5), particularly in feasibility and research reports.

Conclusion

At the beginning of this paper, we suggested that an EST teacher might consider that modal auxiliary verbs do not actually belong to the metalanguage of EST and this view may now seem to be supported up to a certain extent. Results of the analysis of the two corpora indicate that there are no fundamental discrepancies between the way these verbs are utilised in EST and EGP. However we have also seen a number of communicative situations in which some differences do appear, always from a quantitative point of view, hardly ever from a semantic one. This does not mean that there are no pedagogical implications for language teaching : these variations cannot be overlooked and ought to be tackled in order to help the students read, assess and write technical literature.

As said before, compiling the corpora was critical, since the quality of the future research work depended on this. The very nature, genre and topic of some texts may lead to the use or absence of this or that modal verb, thus tending to over-illustrate (or under-illustrate) it in the corpus, thereby altering the future conclusions of the study.

In order to constitute the data-bank, I paid great attention to the following features:

1 – EST corpus

* Date of the texts: all the documents are dated after 1987, and at least 50% of them have been written within the last five years.

* Scientific and technical fields: the chosen texts are representative of the following areas:

- Aerospace Engineering (2%)
- Biology (8%)
- Chemical engineering (5%)
- Chemistry (3%)
- Civil Engineering (4%)
- Computing and IT (19%)
- Electronics and Electrical Engineering (20%)
- Environmental issues (13%)
- Mathematics (4%)
- Mechanical Engineering (22%)

* Number of words of each text: a minimum of 300 words and a maximum of 6,000 so that the corpus had to comprise at least 50 texts. (81 texts actually)

* Genre :

- Announcements for scientific meetings: 2%
- Articles in technical journals on given specialities: 53%
- High School science course book: 2%
- Instructions for the use of machines: 5%
- Manufacturer's product catalogues: 2%
- Popular science reports and other popularisations: 19%
- Research articles: 6%
- Technical reports: 7%
- Technical advertising: 4%

2 – EGP corpus

* Date of the texts: 55% of the documents are less than 10 years old, 30% were written between 1992 and 1960 and 15% in the first part of the twentieth century.

* Number of words of each text: a minimum of 300 words and a maximum of 6,000 so that and the corpus had to comprise at least 50 texts. (74 texts actually).

* Register: most of the documents are written, however the scripts of three authentic conversations (an interview with a judge, another with Commonwealth students in Britain and small talk) have been included, with 9,254 words altogether. When considering the tone, only three documents can be classified as formal and four as rather colloquial. The rest (i.e. 67) are best described as ‘quality written English’ - the one used in most novels, magazines and newspapers. (Very colloquial English has been avoided altogether.)

* Genre: I have tried to be as eclectic as possible with extracts from various sections of various newspapers and magazines (mostly British), informal family documents and letters, and also a large number of extracts from novels and short stories belonging to several sub-genres.

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