DOCUMENT RESUME

ED 202 217 FL 012 277

AUTHOR Coates, Jennifer; Leech, Geoffrey
TITLE The Meanings of the Modals in British and American English.
INSTITUTION York Univ. (England). Dept. of Language.
PUB DATE Sep 80
NOTE 13p.
JOURNAL CIT York Papers in Linguistics; n8 p23-34 Sep 1980

EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS *Contrastive Linguistics; Language Research; *Language Variation; *North American English; Semantics; Syntax; *Verbs
IDENTIFIERS *English (British); *Modal Auxiliary Verbs

ABSTRACT

Some results are reported of an investigation into the meanings of the English modal auxiliary verbs. The corpus consisted of the one million word Brown University corpus of American English and a matching Lancaster University corpus of British English. The three factors operative in the study were: (1) contextual features, that is, co-occurring syntactic/semantic features of the text; (2) British and American English; and (3) differences of genre or style. A theoretical investigation revealed that an appropriate model would have to synthesize six orientations: mono-semantic, polysemantic, categorical, non-categorical, logical, and pragmatic. In addition, a new definition was given to the epistemic/root distinction. Here, epistemic refers to a speaker's belief regarding the truth of a proposition; root refers to a phenomenon which is influenced by some other phenomena. In the four pairs of modals discussed here, should/ought, must/have to, shall/will, and can/may, a compensatory relationship between British and American usage was found in each case. In other words, the American use of the first member of each pair was balanced by the British use of the second member. It is noted, in conclusion, that this analysis of written texts is to be supplemented by an analysis of spoken material. (AMH)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
NATIONAL INSTITUTE OF EDUCATION

THIS DOCUMENT HAS BEEN REPRODUCED EXACTLY AS RECEIVED FROM THE PERSON OR ORGANIZATION ORIGINATING IT. POINTS OF VIEW OR OPINIONS STATED DO NOT NECESSARILY REPRESENT OFFICIAL NATIONAL INSTITUTE OF EDUCATION POSITION OR POLICY

York Papers in Linguistics, 8
September 1980

"PERMISSION TO REPRODUCE THIS MATERIAL HAS BEEN GRANTED BY York Papers TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)."

ED202217

THE MEANINGS OF THE MODALS IN MODERN BRITISH AND AMERICAN ENGLISH*

Jennifer Coates & Geoffrey Leech

(University of Lancaster)

1. *The Corpus*

In this article we report some of the results of an investigation into the meanings of the English modal auxiliary verbs, using data provided by a computer corpus of approximately 2,000,000 words of modern English printed texts. This corpus consists of two sub-corpuses: the 1,000,000 word Brown University corpus of American English, and a matching Lancaster University corpus of British English.

2. *Descriptive Aims*

The modal auxiliaries upon which our investigations focussed were:

can *may* *will* *shall* *must* *ought (to)* *need*

could *might* *would* *should*

We also looked at the quasi-auxiliary *have to* because of its assumed relationship with *must*.

We aimed to investigate the modals quantitatively in relation to:

(a) Contextual features (i.e., coocurring syntactic/semantic features of the text).

(b) British and American English.

(c) Differences of genre or style.

The first of these factors was regarded as an essential part of the investigation, since the interdependence of modal meanings and contextual features such as aspect, agentivity and negation has been assumed (but largely on intuitive grounds) in many previous studies. Associations with contextual features also played a corroborative role in the semantic classification, since once a strong association of this kind had been established, it became an aid to the semantic classification of further textual instances.

The last two factors were also regarded as important. A major difficulty of modal description is undoubtedly variation in usage between different varieties of English. Apart from one or two studies (e.g. Lebrun 1965, Brown and Miller 1975), such variation has been neglected although its existence has been widely acknowledged.

FL 013 411

3. *Theoretical Orientation*

Our theoretical investigations revealed that an appropriate model of modal meanings must synthesize six orientations: mono-semantic, polysemantic, categorical, non-categorical, logical and pragmatic. (For an account of our theoretical conclusions, see Leech and Coates, forthcoming.)

We needed to provide for monosemy as well as polysemy since *can*, unlike the other modals, is essentially monosemantic (see below). We also needed to account for fuzzy or non-categorical distinctions (such as the one between the 'ability' and 'possibility' meanings of *can*); but the fuzzy set model of Zadeh (1971), G. Lakoff (1972) and Leech (1976) is not directly applicable, since modals typically manifest gradients of meaning extending from one pole to another, rather than a single core of meaning with its periphery. Drawing on Quirk's (1965) concept of serial relationship, we have postulated CLINES (using Halliday's term (1961)) of meaning, with textual instances being plotted against an ordered set of diagnostic criteria. In support of our conclusion that modal semantics requires both categorical and non-categorical distinctions, we have noted a striking contrast between epistemic and root uses of the modals: the former appear to be categorical, while the latter are not. That is, we have not needed to make use of the notion of 'cline' in analysing epistemic senses of modals.

3.1 *Root/Epistemic*

We found it necessary to redefine the root/epistemic distinction in the light of our analysis of the modals. Root modality is normally associated with deontic modality (dealing with concepts such as permission and obligation), but our analysis showed that it is necessary to separate two kinds of 'possibility' and 'necessity', namely 'root possibility/necessity', and 'epistemic possibility/necessity'. The root/epistemic distinction therefore cuts across the necessity/obligation and possibility/permission distinctions. (See Leech and Coates, *op. cit.*)

Thus the major interrelations of meaning between CAN (excluding CAN = 'ability'), MAY, MUST, and HAVE TO can be represented as follows (the arrows representing clines):

	Root		*Epistemic*	
CAN MAY	permission ⟷	possibility	possibility	MAY
MUST HAVE TO	obligation ⟷	necessity	necessity	MUST (HAVE TO)

The epistemic/root distinction is interpreted as follows. Epistemic modality imputes a state of belief to the speaker regarding the truth of some proposition X, such that a statement of epistemic 'necessity', for example, takes the form: 'Circumstances constrain the speaker to believe that "X".' In the case of root modality, X refers not to a proposition, but to a phenomenon (an event, state, or set of events), the occurrence of which is influenced by some other phenomena. So we might roughly generalise the form of a statement of root 'necessity' as follows: 'Circumstances constrain the occurrence of X.' Paraphrase criteria, backed up by other criteria (see 4.2), distinguish epistemic and root meaning as follows:

(a) *Epistemic Meaning*

'x may Y' = 'it is possible that x [will] Y' = 'perhaps x [will] Y'.

'x must Y' = 'x must necessarily Y' = 'it must be that Y'.

(b) *Root Meaning*

'x can Y' = 'x may Y' = 'it is possible for x to Y'

'x must Y' = 'it is necessary for x to Y'

These paraphrases are subject to various restrictions and reservations, but illustrate the categorical nature of the epistemic/root distinction. The fact that the items *possible* and *necessary* occur in both epistemic and root paraphrases also provides a basis for using the semantic labels 'possibility' and 'necessity' in both categories.

The contrast between 'permission'/'obligation' and 'possibility'/'necessity' is often assumed to be categorical, but we found it more accurate to describe it in terms of a cline of RESTRICTION. At one end of the scale the nature of the determining or constraining circumstances is unrestricted, while at the other end they belong to a restricted world of man-made freedoms and obligations. It is here that a paraphrase such as 'x is permitted to Y' becomes more appropriate than 'it is possible for x to Y'. The postulation of such a cline would not be necessary but for the existence of intermediate 'unclear cases', for which neither type of paraphrase is adequate:

'It's too damn busy in here. We *can't* expect him to leave his customers.'

Neither 'It is impossible for us to expect . . .' nor 'We are not permitted to expect . . .' would capture the sense of *can't* here. This use of *can* is not unrestricted, in that the event referred to is clearly possible, in an absolute sense, but is forbidden by a man-made code of 'reasonable behaviour'. On the other hand, it is not fully restricted, in that the prohibition cannot be attributed to a particular human agent or agency, as it can in clear cases of 'permission'.

3.2 *The 'Quantitative Stereotype'*

For the purposes of corpus analysis, we made use of traditional notional categories such as 'ability' and 'permission', while excluding from the count 'unclear cases' (i.e., textual instances which could not be assigned to one category or another, because of their intermediate position on a cline). Our analysis indicates that the majority of examples can be accounted for by using these categories; this suggests that the semantic interpretation of modals proceeds by identifying an instance as conforming to a particular stereotype, established by quantitative predominance. If this is the case, operating with categories such as 'permission', 'ability', etc. (while allowing for 'unclear cases') is not a distortion, but a justifiable simplication, of the data.

4. *Descriptive Findings*

Our descriptive findings will be discussed (a) on a general level, and then in relation to (b) contextual features, (c) British and American English; differences of genre or style will be dealt with as they arise in relation to these three subheadings.

4.1 *General Findings*

Bearing in mind that these findings are based solely on written material (that is, the proportions may be different in spoken English), we can say that some modal auxiliaries occur much more frequently than others. The table below gives the total number in the corpus for each modal, in order of frequency, followed by figures for the British and American sub-corpuses separately.

MODAL	TOTAL (whole corpus)	TOTAL (British)	TOTAL (American)
WOULD	6147	3002	3145
WILL	5500	2804	2696
CAN	4327	2141	2186
COULD	3520	1744	1776
MAY	2620	1323	1297
SHOULD	2195	1285	910
MUST	2142	1131	1011
MIGHT	1444	775	669
HAVE TO	1343	696	647
SHALL	620	352	268
OUGHT	173	105	68
NEED	112	72	40
TOTAL	30143	15430	14713
(PERHAPS)	(704)	(388)	(316)

5

NOTE: The figures in this table are subject to slight revision due to errors existing in the British corpus at the time of the study. The likely result of such modification is that the British figures will increase on average by 0.2 per cent.

The adverb PERHAPS, which expresses the same modality as epistemic MAY, MIGHT and COULD, is included to give some idea of the frequency of the modal auxiliaries relative to adverbial forms.

These crude totals give no indication of sub-divisions based on (for example) the root/epistemic distinction. To clarify the table therefore the following list indicates which usage is most important for each modal; a semantic label is given, followed by the percentage that the usage constitutes. (Here again, the bias of a written corpus is evident - we presume that, for example, CAN in the root sense of 'permission' would be better represented in a spoken corpus.)

MODAL	MOST COMMON SENSE	
WOULD	Hypothetical	(55%)
WILL	'Prediction'	(60%)
CAN	Root 'Possibility'	(68%)
COULD	Root 'Possibility' (past) Root 'Ability' (past)	(30%) (33%)
MAY	Epistemic 'Possibility'	(64%)
SHOULD	Root 'Obligation'	(65%)
MUST	Root 'Obligation and Necessity'	(70%)
MIGHT	Epistemic 'Possibility' (past and non-past)	(60%)
HAVE TO	Root 'Obligation and Necessity'	
SHALL	(See 4.3(c) below)	
OUGHT	Root 'Obligation'	(85%)

The most important finding here is the clear difference in distribution of CAN and MAY, which have so often been lumped together in work on the modals: Lebrun (1965), for example, describes them as synonyms in free variation. Although they overlap in the root 'permission' and root 'possibility' senses, their chief usages are quite distinct: CAN is the normal modal for the expression of root 'possibility' (MAY is used in this way in very formal contexts, such as learned articles), while MAY's chief function is to express epistemic 'possibility'; CAN cannot be substituted for MAY in this usage:

I *may* not get back there today - it depends on the work here.

It is also important to realise that MIGHT expresses epistemic 'possibility' not just as the past form of MAY but also in non-past contexts:

Total investment this year is estimated at £1,755 million. And next year ... it *might* be £200 million more.

4.2 *Contextual Features*

Working with the categories root and epistemic as described above (see 3.1), and excluding unclear cases, we were able to establish certain relationships between contextual features and meaning. In other words, analysis of instances conforming to the 'quantitative stereotype' enabled us to establish clear co-occurrence relations. It seems to us that the fact that 100 per cent associations were established in certain important cases for epistemic meaning helps to justify our interpretation of the root-epistemic division.

In general, we found that certain contextual features are associated with a certain category. In particular, the variables Existential subject, Aspect (Progressive and Perfective), and Quasi-modal Verbs were strongly associated with Epistemic meaning. Specific examples are:

(i) *Epistemic MUST* (British sub-corpus)

Existential subject $\supset^{100}$ Epistemic (where $x \supset^{z} y$ means 'z is the probability (expressed as a percentage) of y occurring in the presence of x'), e.g.:

I cannot will what is impossible and therefore *there must be* a God who is able and willing to bring about the Supreme Good.

Progressive Aspect $\supset^{100}$ Epistemic, e.g.:

She *must be touching* up her hair, it never used to be quite that auburn shade.

Perfective Aspect $\supset^{99}$ Epistemic, e.g.

At one time Tarrant had felt almost sure that the C.I.D. *must have learned* of his meetings with Haines.

(ii) *Epistemic MAY*

Existential Subject $\supset^{100}$ Epistemic, e.g.:

Or perhaps *there may be* a third way out of the difficulty ...

Perfective Aspect $\supset^{100}$ Epistemic, e.g.:

... this perhaps lends support to the conjecture ... that it *may not have been* quite finished in time for the first performance.

Quasi-modal $\supset^{100}$ Epistemic, e.g.:

... though occasionally, with a really determined pursuer, stronger means *may have to be* adopted.

Stative verbs are also associated with epistemic meaning, but with a lower probability value:

Stative Verb $\supset^{90}$ Epistemic, e.g.:

I have made a discovery, sir. It *may be* of no account but I think that you will find it interesting.

The variables Agentive Verb, Animate Subject, Negation, and Passive Voice co-occur significantly with root meaning. The implication values of these variables for individual modals are usually lower than those found with variables associated with epistemic meaning. This finding is in-keeping with the non-categorical nature of root modals (cf. 3.1). The following examples illustrate these associations:

MUST Agentive Verb $\supset^{86}$ Root.

e.g. We *must end* the idea of war.

SHOULD Animate Subject $\supset^{75}$ Root.

e.g. *Everyone should* take time to read Martin Luther's hymn.

WILL 1st Person Subject $\supset^{80}$ Root.

e.g. *I will* come with you tomorrow, but more than that I cannot promise.

OUGHT Negation $\supset^{100}$ Root. (This finding is probably due to the small number of instances of epistemic OUGHT in the sample.)

e.g. As Bishop Talbot had told me that I *ought not to* spend many years in Tatsfield ....

MUST Passive Voice $\supset^{95}$ Root.

e.g. Provision *must be made* for the incorporation of shops in at least two-thirds of the frontage.

We were able to build up a quantitative profile of each modal in this way, listing all significant correlations. As the above examples will have indicated, MUST can very easily be defined in terms of contextual features. This is because with MUST we are concerned primarily with the binary opposition root-epistemic. With the other modals the general picture is more complex, due to other distinctions such as past-nonpast, hypothetical-nonhypothetical. The essentially monosemantic nature of CAN (see 3.1) is confirmed by the lack of strong correlations between different uses of CAN and different contextual features; this finding is consistent with the concept of a CLINE. The meanings of CAN are distributed along gradients with no absolute cut-off points.

Several other strong, but no unpredictable, modal-specific associations were established. For example, with SHALL, 3rd person subjects correlate with the (obsolescent) root meaning of obligation:

... but there is power for the Treasury, by statutory instrument, to order that division *shall* be into unequal parts.

While the interrogative is found only with root sense of volition where the speaker consults the hearer's wishes:

Shall we flip a coin to see which of us goes first?

In the British material there was a significant association between first person subjects and hypothetical SHOULD (that is, SHOULD operating as a first person variant of WOULD); e.g.:

I *should* imagine that this subject matter looked quite exciting in colour.

The use of SHOULD as a 'subjunctive' form was associated with the feature Subordinate Clause; e.g.:

It is in Russia's interest that Poland *should* be strong and powerful.

4.3 *Differences in British and American modals*

After analysis of a random sample of all the modals had been carried out, the British and American results were compared. The X^2 test of statistical significance was applied to these results, and we discuss here those modals where a significant difference between American and British usage emerged. They are SHOULD (and OUGHT), MUST and HAVE TO, SHALL, CAN and MAY.

(a) *SHOULD (and OUGHT)*

The table below gives details of the total numbers of SHOULD, the numbers in each sample of approximately 200 , and the figures in each sample for each semantic category including minor uses. Here and elsewhere, the table on the right expresses the same distributions in terms of a standardised total of 200.

(The method of sampling was to take each nth instance in each sub-corpus, where n was the nearest whole number less than m = total instances of a modal in sub-corpus ÷ 200. This yielded a sample of 400+ instances of each modal.)

	British	American	British	American
SHOULD				
root	116	161	111.54	142.48
epistemic	28	24	26.92	21.24
subjunctive	38	26	36.54	23.01
Would variant	23	11	22.12	9.73
Shall variant (past form etc)	3	4	2.88	3.54
Number in sample	208	226	200.00	200.00
Total in corpus	1272	910	X^2 =	13.44

As will be observed, whereas 73 per cent of the American sample has the root meaning, only 57 per cent of the British sample does. The unexpectedly large British total for SHOULD is clearly the result of its frequency as a 'subjunctive' and as a first person variant for WOULD. The fact that root SHOULD is less frequent in British English than in American can possibly be accounted for by the relative frequency of OUGHT in British English. (The numbers involved for OUGHT are very small. However, they do show that, while epistemic OUGHT is used with similar frequency - or rather infrequency - in American and British English, examples of root OUGHT are much more frequent in British English, presumably to supply an unambiguous alternative to SHOULD). In American English, just as WILL has virtually superseded SHALL as the first person form of the WILL paradigm, so SHOULD is uncommon as a first person variant of WOULD. The less frequent use of 'subjunctive' SHOULD in American English is possibly related to the supposed greater frequency of the present subjunctive in that variety.

(b) *MUST and HAVE TO*

	British	American	British	American
MUST root	153	150	134.80	152.30
MUST epistemic	74	47	65.20	47.70
sample total	227	197	200.00	200.00
			X^2 =	3.95

	British	American	British	American
HAVE TO root	226	209	198.30	191.70
HAVE TO epistemic	2	9	1.70	8.30
sample total	228	218	200.00	200.00
			X^2 =	4.88

The X^2 test confirmed our suspicions that these differences were significant. In other words, epistemic MUST occurs significantly more frequently in the British material than in the American, and root MUST significantly less so. Balancing this, we find (although occurrences are rare) that epistemic HAVE TO occurs significantly less frequently in the British material than in the American. The flavour of 'Americanism' in examples like this one from the corpus: *This has got to be some kind of local phenomenon*, is confirmed by our finding; that is, to express

'epistemic necessity', (see 3.1) American speakers/writers have a certain tendency to select HAVE TO while British speakers/writers choose MUST.

The distribution of MUST in terms of fiction and non-fiction texts is also revealing when British and American examples are compared:

British	Non-fiction :	72.82%	Fiction :	27.18%
American	Non-fiction :	82.33%	Fiction :	17.67%

Since fiction texts in the corpus actually constitute c.25 per cent of all texts, the British material clearly displays virtually the expected frequencies. The American material, on the other hand, is skewed, with more examples of MUST appearing in the non-fiction texts than we would expect. This seems to be due to the large quantities of informal 'spoken' dialogue in the fiction texts. Since in the American texts we found a disproportionately high number of HAVE TO's in the fiction texts, we may tentatively suggest a generalisation 'MUST = formal, HAVE TO = informal' for American English. This is not a simple question of HAVE TO being favoured in American English at the expense of MUST, since the British material contains more HAVE TO's as well as more MUSTs. But in British English, MUST and HAVE TO are closer to a state of stylistic free variation (allowing for differences like the presence of absence of Discourse Orientation (see Palmer 1974) or of a past tense form).

(c) *SHALL*

Examples of SHALL from the corpus were analysed in terms of the root-epistemic distinction, with the root category being sub-divided into three: 'root obligation', 'root intention' and 'root volition' (= 'hearer's wishes consulted'). When the figures for the British and American sub-corpuses were compared and submitted to the X^2 test (with three degrees of freedom), we discovered significant differences in usage ($X^2 = 20.93$). Most strikingly, we found that 'root obligation' accounted for over 50 per cent of the American examples sampled. Although the totals for the whole corpus (see 4.1) show what one would expect, i.e. that SHALL occurs more frequently in British English, the 269 examples found in the American sub-corpus do not represent unspecialised everyday usage: they are mostly restricted to legal contexts.

SHALL clearly functions quite differently in British and American English. In British English, it is used in its obligation sense in legal contexts, but far less so, in our sample, than in American English. In British English, SHALL is most commonly found in its 'predictive' (future) sense, as a first-person variant for WILL. This use is rare in American English, where WILL is almost universally used. The 'root volition' sense of intention provides 25 per cent of American SHALLs, which is rather surprising. But all these occur in highly formal contexts - in the speeches of politicians and in the learned articles of academics - so it seems that SHALL survives in American English largely as a formal variant of WILL or as an archaic way of stipulating an obligation.

These differences in American and British usage are reflected in the distribution of SHALL in the corpus. In the British material, we found 71.14 per cent of examples in the non-fiction texts and 28.86 per cent in the fiction texts (compared with the expected proportions of 75 per cent-25 per cent). That is, there was if anything a slight bias towards informal style. The American material, on the other hand, has 89.17 per cent of its examples in the non-fiction texts and only 10.83 per cent in the fiction texts - a definite formal bias. Thirty-seven per cent of all American examples occur in category H, a category largely devoted to government documents. Since this category only represents six per cent of the corpus, it is clear that usage of SHALL is very restricted. If this category were to be omitted, the contrast between British and American usage would be even more apparent.

(d) *CAN and MAY*

The root permission sense of CAN (although probably under-represented in the corpus - see 4.1) was found to be less common in American than in British English. This finding is balanced by the fact that the root permission sense of MAY is more common in American English, and is so distributed as to support our impression that written English in the States is more formal than in Britain. The formal-informal contrast between written and spoken English seems to be greater in American English. CAN (= 'root permission') has a firm hold in British English despite educational pressures (backed by prescriptives), while American English is more conservative in this respect.

(e) *Summary of Findings*

In the pairs of modals discussed here - SHOULD/OUGHT, MUST/HAVE TO, SHALL/WILL, CAN/MAY - a compensatory relationship was found in each case to obtain between British and American usage. The American use of root SHOULD was balanced by the equivalent British use of root OUGHT; the American use of epistemic HAVE TO corresponded to the British use of epistemic MUST; the American use of epistemic WILL was counterbalanced by the British use of epistemic SHALL; the American use of root MAY was balanced by the British use of root CAN.

Our general conclusion from these differences is that in American English SHALL and OUGHT are rare and apparently obsolescent, their main senses being expressed by WILL and SHOULD respectively. Moreover, American English tends to categorise the modals in formal-informal terms, leading to specialisation, particularly in the case of SHALL and MAY. On the other hand, British English preserves a more general use of modal auxiliaries, with each modal covering more ground, both semantically and stylistically.

5. *Conclusions*

We feel that the analysis of a corpus of written texts should be supplemented by an analysis of spoken material. We intend to use for this purpose the spoken corpus of the Survey of English Usage to which Professor Randolph Quirk has kindly given us access. We should also like to

undertake informant tests, in order to discover, for example, how far the paraphrase and substitution tests we have used can be given a more objective validity. Our work so far tends to confirm the impression that differences between modal usage in written and spoken English are considerable, and suggests that a thorough analysis of spoken texts will add an important new dimension to our present findings.

* We are grateful to the SSRC for their funding of this project. Further details of the corpus and our findings can be found in our Final Report to the SSRC: Project JR 3792/1.

REFERENCES

Brown, K. and Miller, J. (1975) 'Modal verbs in Scottish English', *Work in Progress* No 8, Department of Linguistics, University of Edinburgh, 99-114.

Halliday, M.A.K. (1961) 'Categories of the theory of grammar', *Word* 17, 241-92.

Lakoff, G. (1972) 'Hedges: a study in meaning criteria and the logic of fuzzy concepts', in *Papers from the Eighth Regional Meeting of the Chicago Linguistic Society*, 183-228.

Lebrun, Y. (1965) *'Can' and 'May' in Present-Day English*. Presses Universitaires de Bruxelles.

Leech, G.N. (1976) 'Being precise about lexical vagueness', in *York Papers in Linguistics*, 5, 149-165.

Leech, G.N. and Coates, J. (Forthcoming) 'Semantic indeterminacy and the Modals', to be published in Greenbaum *et al* (ed), *Studies in English Linguistics*, London 1980.

Quirk, R. (1965) 'Descriptive statement and serial relationship', *Language* 41, 205-217.

Zadeh, L. (1971) 'Quantitative fuzzy semantics', *Information Sciences*, 3, 159-76.