

INTERACTIVE RELATIONS BETWEEN SENSES OF QUASI-MODALS IN DIFFERENT SUBJECTIVITY RESTRICTION GRADIENTS AND SYNTACTIC AND SEMANTIC FEATURES

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ABSTRACT. *Subjectivity restriction gradience of word senses has been a controversial and hard issue in linguistic studies. Finding out how different syntactic and semantic features affect the senses of a modal verb in different subjectivity restriction gradients is an even tougher and significant issue in both linguistic studies and natural language processing, because it may reveal the sensitivity of different linguistic features to the word senses in the subjectivity restriction gradients. However, no studies on this issue have been found. Therefore, in this paper, taking English quasi-modal verb “have to” as a target word, we investigate the interactive relations between its syntactic and semantic features and subjectivity restriction gradience. Nine co-occurred syntactic features and 3 semantic features are selected and used for the construction of the formal context of the dataset of “have to” with 5 subjectivity restriction gradients. An attribute partial-ordered structure diagram is generated based on the formal context for the knowledge discovery. The distributive structures of the linguistic features in the 5 subjectivity restriction gradients are visualized and the interactive relations between the senses of “have to” at different subjectivity restriction gradients and the co-occurred syntactic and semantic features are discovered. The discovered knowledge provides significant and useful evidence for both the semantic analysis in modal semantic studies and the feature selection in natural language processing.*

Keywords: English quasi-modal verbs, Subjectivity restriction gradience, Syntactic and semantic feature, Attribute partial-ordered structure diagram

1. Introduction. Subjectivity has been widely considered as an important and influential factor for a word sense, especially for the senses of modal verbs, because it relates to a speaker’s attitude, belief and opinion. Usually, subjectivity has a gradience from strong to weak, and the weakest subjectivity is objectivity. Subjectivity restrictions are the implicit restrictions related to the subjectivity of word senses, and they also have gradience from strong to weak. Syntactic and semantic features are also believed to be restrictive to the sense of a modal word. To investigate the interactive relations between the senses of a modal verb in different subjectivity restriction gradience and the co-occurred syntactic and semantic features is a novel dimension for knowledge discovery in both semantic study of modal auxiliaries and natural language processing. There are some related studies. In semantic studies, Zhang [1,2] studied subjectivity of deontic modality, epistemic modality and dynamic modality to explain the relationship between subjectivity and modality system. Verstraete [3] distinguished subjective modality from objective modality from the perspective of the interpersonal and ideational functions of English modal auxiliary, and summarized that dynamic modals are always objective. And epistemic modality is subjective. Deontic modality is both subjective and objective. Shen [4] elaborated

subjectivity and subjectification in Mandarin. Collins [5] comprehensively discussed the semantic properties of the quasi-modals in English. Tang and Yang [6] described the ambiguity of English modal verbs and analyzed the phenomena from the perspective of prototype category theory. In the studies of natural language processing, Yu et al. [7] investigated the interactive relations between semantic and syntactic features in the word sense disambiguation of English modal verbs. They [8] have also studied the restriction of time, aspect and voice on the senses of English modal verbs. Fu et al. [9] studied the influence of different subjective factors to WSD of English modal verb *can*. Li and Yu [10] analyzed attribute significance of English modal verbs in word sense disambiguation. Banea et al. [11] studied on sense-level subjectivity in a multilingual setting. Akkaya et al. [12] presented an iterative constrained clustering method which greatly increased the efficiency of subjectivity word sense disambiguation. Biyani et al. [13] used subjectivity analysis to improve thread retrieval in online forums. Ortega [14] examined the notion of subjectivity by drawing parallels between Lacanian theory and Bayesian probability theory. The previous studies laid a solid foundation for semantic studies and natural language processing of modal verbs. However, they did not consider the interactive relations between the word senses in different subjectivity restriction gradients and the syntactic and semantic features. Since subjectivity restriction co-occurs with syntactic and semantic features and they work simultaneously in generating the senses of a modal verb, to find out how they interact with each other may provide valuable evidence and reference for both the studies of semantics of modal verbs and the feature selection in natural language processing. Therefore, this paper focuses on this issue. The English quasi-modal *have to* is chosen as the target word. The approach of attribute partial-ordered structure diagram (APOSD) is used since this approach can visualize the hierarchical and horizontal structures of the dataset which is suitable for knowledge discovery.

The layout of the paper is as the following. Chapter 1 introduces the related studies and the space for this study. Chapter 2 elaborates the sense categorization and the subjectivity restriction gradient for *have to*. Chapter 3 explains the feature selection and data preparation for this study. Chapter 4 describes the theoretical foundation of the study. Chapter 5 presents the procedure and the results of the knowledge discovery. Chapter 6 comes to the conclusion.

2. Sense Categorization and Subjectivity Restriction Gradient of *have to*.

According to the Semantics of Modal Auxiliaries [15], the senses of English quasi-modal *have to* can be classified into three senses, including root obligation (RO*have to*), root necessity (RN*have to*) and epistemic necessity (EN*have to*), as shown in Table 1.

The subjectivity restriction gradient of *have to* is determined with the reference to Coates and Leech's restriction gradient of *can* [16]. Considering subjectivity being a result of the interaction of a speaker's mental world and the restriction of context, we

TABLE 1. Sense categorization of *have to*

Senses of <i>have to</i>	Definition	Examples
Root obligation (RO <i>have to</i>)	Something is obligatory or someone has the duty to do something	You always <i>have to</i> obey the law.
Root necessity (RN <i>have to</i>)	Something is necessarily required by someone or something	That means I <i>have to</i> find him.
Epistemic necessity (EN <i>have to</i>)	Something is logically necessary	I do not think it <i>has to</i> rain when it is cloudy.

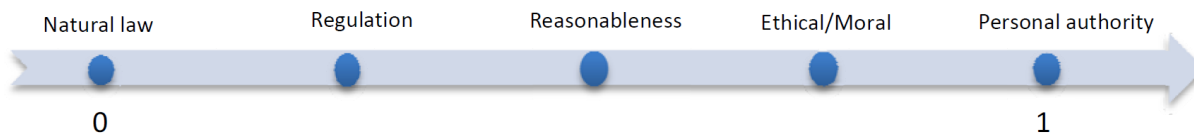


FIGURE 1. Subjectivity restriction gradience of *have to*

readjusted the order of the gradients by Coates and Leech with the consideration of subjectivity. The established subjectivity restriction gradience is shown in Figure 1.

In Figure 1, natural law means the speaker’s subjectivity under the restriction of natural law; personal authority means the speaker’s subjectivity under the restriction of personal authority. The others are explained in the same way. The subjectivity restriction gradience changes from weak restriction (0) to strong restriction (1). The following study is based on this subjectivity restriction gradience.

3. Feature Selection and Data Preparation. The features used in this study include semantic features and syntactic features. The semantic features include the 3 senses of *have to*; the syntactic features are selected based on the co-occurrence frequency and the relativity of *have to* and subjectivity. The selected semantic and syntactic features are represented with *ai*, as shown in Table 2.

TABLE 2. Selected features

<i>ai</i>	syntactic features	<i>ai</i>	syntactic features	<i>ai</i>	semantic features
a1	first person subject	a6	agentive predicate	a10	sense of RO <i>have to</i>
a2	second person subject	a7	patient predicate	a11	sense of RN <i>have to</i>
a3	third person subject	a8	mental predicate	a12	sense of EN <i>have to</i>
a4	inanimate subject	a9	speaker involvement		
a5	animate subject				

The data for this study are from a 2.5 million words corpus which consists of materials from different genres, including law, literature work, news report, academic paper, interview, speech, movie subtitle, science fiction popular science books, scientific forum, book review and introduction to products. The materials are evenly extracted from each genre. Based on the 5 subjectivity restriction gradients shown in Figure 1, 30 sample sentences are selected for each gradient; therefore, totally 150 sample sentences are selected, and their syntactic features are tagged with 1 if a sample sentence has the feature; otherwise, a 0 is tagged. We use the 3 senses of *have to* as the semantic features. The occurrence of the 3 senses of *have to* is counted and shown in Figure 2. In Figure 2, (a) represents personal authority; (b) represents ethical/moral restriction; (c) represents reasonableness restriction; (d) represents regulation restriction and (e) represents natural law restriction.

As we can see from Figure 2, there is no occurrence of RO*have to* in the natural law restriction gradient, and EN*have to* only occur once in the gradient. This implies that the senses of *have to* are sensitive to the subjectivity restrictions.

The semantic features are also given bi-values 1 or 0. If the *have to* in a sample sentence has one of the 3 senses, it is given 1; otherwise, it is given 0.

By now the data for this study are prepared and the formal context for discovering the interactive relations between the senses of *have to* in the 5 subjectivity restriction gradients and the co-occurred syntactic and semantic features can be constructed, as shown in Table 3.

4. Theoretical Foundation. In this study, the approach of the attribute partial-order structure diagram approach is used in order to find the interactive relations between the

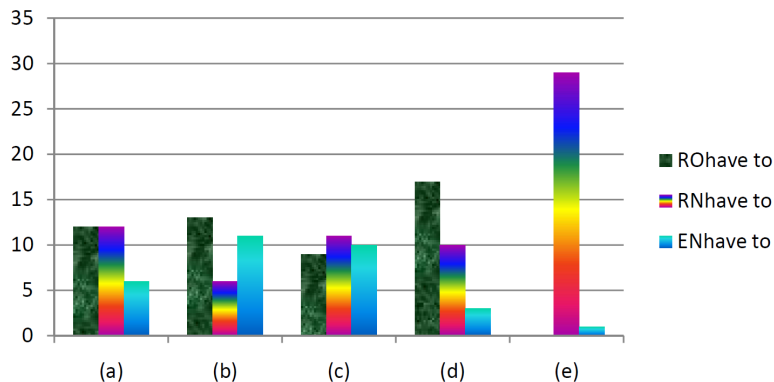


FIGURE 2. Occurrence of 3 senses of *have to* in 5 subjectivity restriction gradients

TABLE 3. Formal context of *have to*

$j(g) \backslash a_i$	a1	a2	a3	a4	a5	a6	a7	a8	a9	a10	a11	a12
1(a)		1			1	1			1	1		
2(a)		1			1	1		1	1	1		
3(a)		1			1	1			1		1	
4(a)		1			1	1			1		1	
5(a)		1			1	1			1	1		
6(a)			1		1	1			1	1		
7(a)	1				1	1			1	1		
8(a)		1			1	1			1	1		
9(a)			1		1	1			1	1		
10(a)		1			1	1			1	1		
...
141(e)			1	1		1						1
142(e)			1		1	1						1
143(e)			1	1		1						1
144(e)			1	1			1					1
145(e)			1	1			1					1
146(e)			1	1		1						1
147(e)			1	1		1						1
148(e)			1	1		1						1
149(e)			1		1	1						1
150(e)			1	1			1					1

senses of *have to* in the subjectivity restriction gradients and the syntactic and semantic features. The approach is based on the following theoretical foundation of formal context [17,18].

Definition 4.1. A formal context $K = (U, M, I)$ consists of two sets U and M and a relation I between U and M . The elements of U are called objects and the elements of M are called attributes of the context. I represents the relation between an object u and an attribute m , written as uIm or $(u, m) \in I$.

Definition 4.2. Let $K = (U, M, I)$ be a formal context, for a set $A \subseteq U$, $f(A) = \{m \in M | (u, m) \in I, \forall u \in A\}$. Correspondingly, for a set $B \subseteq M$, define $g(B) = \{u \in U | (u, m) \in I, \forall m \in B\}$. A formal concept is a pair (A, B) with $A \subseteq U$, $B \subseteq M$, $f(A) = B$ and $g(B) = A$. A is called the extent of the concept and B is called the intent of the concept.

Definition 4.3. A binary relation I on a set M is called a partial order relation, if it satisfies the following conditions for all elements $x, y, z \in M$:

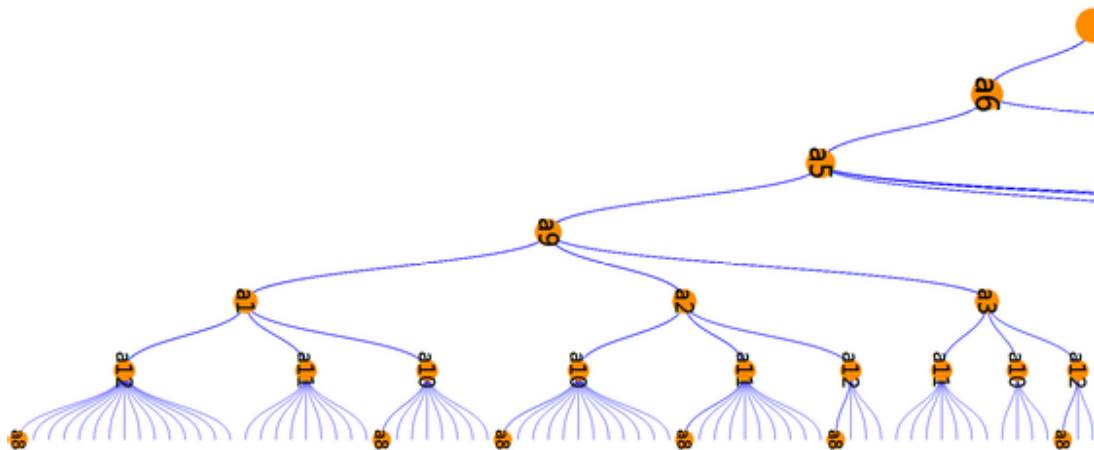
- 1) xRx (reflexivity)
- 2) xRy and $x \neq y \rightarrow$ not yRx (antisymmetry)
- 3) xRy and $yRz \rightarrow xRz$ (transitivity)

Definition 4.4. If (A_1, B_1) and (A_2, B_2) are concepts of a context, (A_1, B_1) is called a subconcept of (A_2, B_2) , if $A_1 \subseteq A_2$ (which is equivalent to $B_2 \subseteq B_1$). In this case, (A_2, B_2) is a superconcept of (A_1, B_1) , and we write $(A_1, B_1) \leq (A_2, B_2)$. The relation \leq is called the hierarchical order of the concepts.

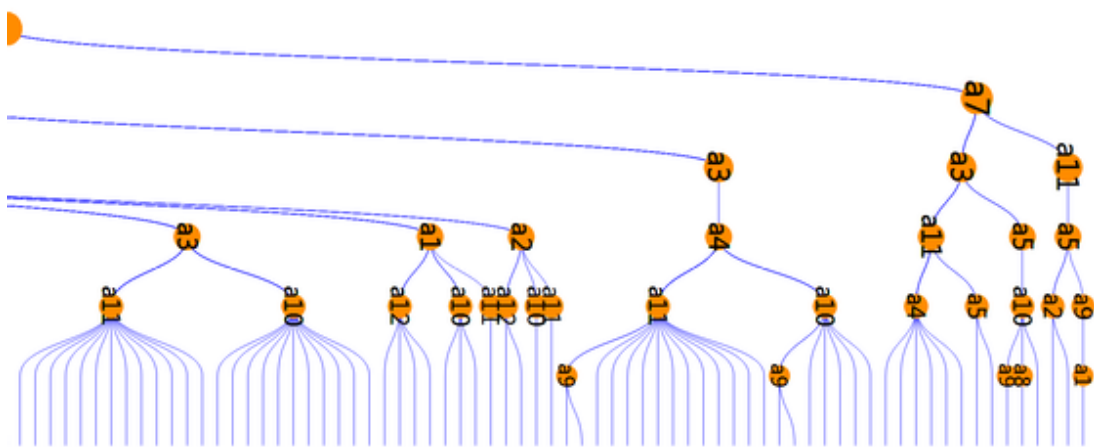
5. Knowledge Discovery. By using a SPOAD software [18], an attribute partial-order structure diagram for knowledge discovery of *have to* can be generated based on the formal context in Table 3, as shown in Figure 3, which can be used as a model for discovering the hierarchical distribution of the attributes.

It can be seen from the data structure in Figure 3 that syntactic features ($a1$ - $a9$) work together with semantic features ($a10$ - $a12$) to form the senses of *have to*. Generally, syntactic features occur at the upper layers as the extent attributes and semantic features occur at the lower layers as the intent attributes. This implies that syntactic features have the function of generalization, and semantic features have the function of specification.

Figure 4 shows the occurrence of different syntactic features in the 5 subjectivity restriction gradients. As we can see from Figure 4(a) that the second person subject has



(a) The first half of the APOSD



(b) The second half of the APOSD

FIGURE 3. Attribute partial-order structure diagram (APOSD) of *have to*

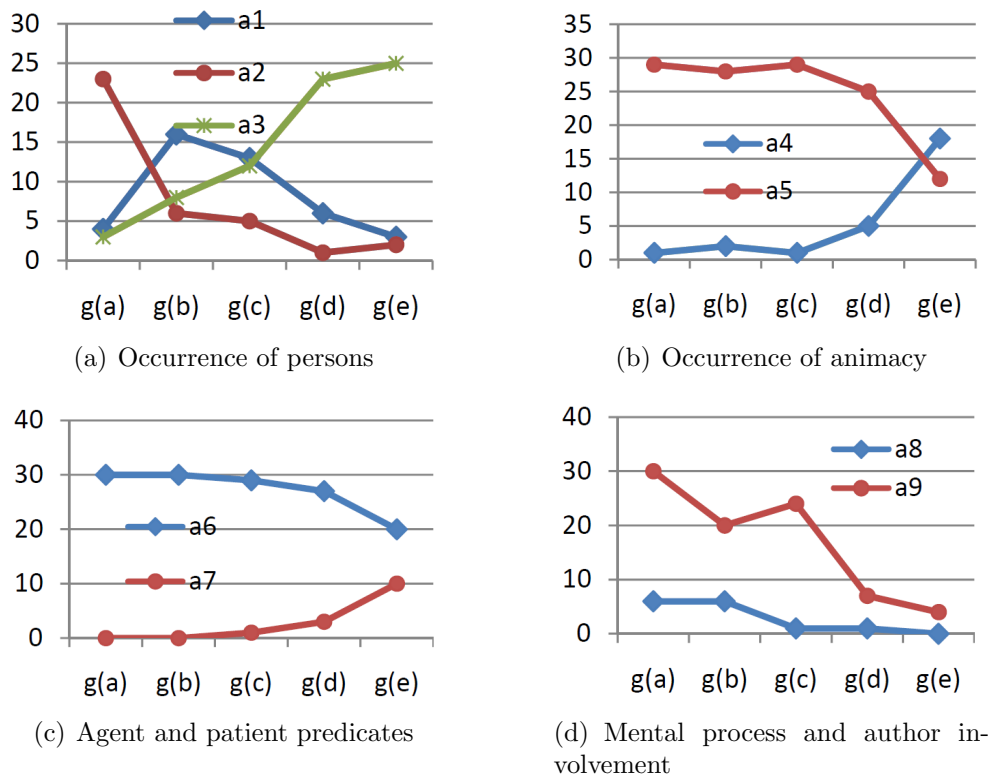


FIGURE 4. Occurrence of different syntactic features in the 5 gradients

the highest occurrence in gradient (a) and the first person subject has the highest occurrence in gradient (b), and they both gradually decrease along the subjectivity restriction gradient from (a) to (e), *i.e.*, from strong subjectivity restriction to weak subjectivity restriction. On the contrary, the occurrence of the third person subject increases along the subjectivity restriction gradient, *i.e.*, from the low occurrence at gradient (a) to the high occurrence at gradient (e). These imply that the features of first and second person subjects support the strong subjectivity, and the feature of third person subject supports weak subjectivity. Figure 4(b) shows the occurrences of the feature of subject animacy. Feature *a4* represents inanimate subject and *a5* represents animate subject. It can be seen that the occurrence of animate subject changes from strong to weak along the subjectivity restriction gradient, and the one for inanimate subject changes in the opposite way, which implies that the feature of animate subject supports the strong subjectivity and the feature of inanimate subject supports the weak subjectivity. Figure 4(c) shows the occurrences of agentive predicate and patient predicate. It can be seen that the occurrence of agentive predicate gradually decreases from strong subjectivity restriction (a) to weak subjectivity restriction (e); on the contrary, the one for patient predicate gradually increases, which implies that the feature of agentive predicate supports the strong subjectivity, while patient predicate supports the weak subjectivity. Figure 4(d) shows the change tendencies of the occurrences of the feature of mental process predicate (*a8*) and the feature of speaker involvement (*a9*). As we can see, both of them decrease along the subjectivity restriction gradient from strong to weak restrictions. This may imply that they are the features supporting strong subjectivity restriction. As far as the semantic features are concerned, as we can see from Figure 2, in gradient *g(e)*, almost only the sense of *RNhave to* occurs, and the other 2 senses almost do not occur, which implies that the sense of *RNhave to* supports the weak subjectivity.

The interactive relations between the senses of *have to* in the subjectivity restriction gradients and the syntactic and semantic features found in Figure 4 are summarized as

TABLE 4. Features supporting subjectivity of *have to*

Features supporting strong subjectivity	Features supporting weak subjectivity
first person subject	third person subject
second person subject	inanimate subject
animate subject	patient predicate
agentive predicate	RN <i>have to</i>
mental process predicate	
speaker involvement	

some syntactic and semantic features supporting the subjectivity of *have to*, as shown in Table 4.

6. Conclusions. In this paper, the interactive relations between the senses of *have to* in the subjectivity restriction gradients and the syntactic and semantic features are studied. Three senses of *have to* are categorized. The subjectivity restriction gradient of *have to* is established and used in the knowledge discovery. It is found that syntactic and semantic features work together to form the senses of *have to* in the different subjectivity restriction gradients. Generally, syntactic features have the function of generalization, and semantic features have the function of specification. Some features tend to support the strong subjectivity, such features as the first person subject, second person subject, animate subject, agentive predicate, mental process predicate and speaker involvement; and some features tend to support weak subjectivity, such as the third person subject, inanimate subject, patient predicate and the semantic feature of RN*have to*. These findings provide valuable and very useful evidence and reference for the semantic study of quasi-modal verbs and the feature selection in natural language processing. In the further study, we will work on the calculation of the membership degree of subjectivity of quasi-modals.

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