The linguistic representation of conceptual structure: applications for teaching reading comprehension

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Resumen

Este artículo utiliza los resultados de las investigaciones de Meagher (1999, 2004) para desarrollar estrategias que aumenten la comprensión de lectura en áreas científicas. Estudian la manera en que los esquemas semánticos se relacionan con procesos discursivos. El objetivo general de Meagher (1999), basado en Jackendoff (1983, 1990), es elaborar una metodología para la apreciación de los conceptos que tienen los novatos y los expertos sobre el aprendizaje a través de una aprehensión de esquemas subyacentes. Meagher (2004), desde la perspectiva de la dinámica de fuerzas de Talmy (1985, 2000), examina cómo las distintas nociones semánticas se combinan con el sistema de la dinámica de fuerzas para brindar dirección al discurso. Ambos proyectos se refieren a la construcción del significado a nivel de discurso y estudian la manera en que la información gramatical subléxica estructura el significado en corpora *auténticos. Por lo tanto, los resultados terminan validando los postulados teóricos de Jackendoff y Talmy. La comprensión de estas estructuras conceptuales subyacentes es de gran utilidad para hispano-parlantes confrontados con la tarea de leer textos científicos en inglés.*

Palabras clave: comprensión de lectura, esquemas semánticos, procesos discursivos, dinámica de fuerzas, inglés para propósitos específicos

Fecha de recepción del artículo: 19 de septiembre de 2005
Fecha de aceptación de versión revisada: 8 de enero de 2007

Abstract

This article applies the research results of Meagher (1999, 2004) to the development of strategies for increasing reading comprehension in English for Specific Purposes (ESP) courses. It concentrates on the way semantic schemas are related to discourse processes. The general objective of Meagher (1999), based on Jackendoff (1983, 1990), is the elaboration of methodology for grasping novice/expert concepts of the learning process through an apprehension of underlying schemas, while Meagher (2004), from the perspective of Talmy's force dynamics (1985, 2000), pretends to examine how distinct semantic notions combine with the force dynamic system giving direction to discourse. Both projects deal with the construction of meaning at discourse level and study the manner in which sub-lexical grammatical information structures meaning in authentic corpora*. Thus, results validate theoretical postulations by Jackendoff and Talmy. An understanding of these underlying conceptual structures is of great use to Spanish speaking students faced with the task of reading scientific texts in English.*

Keywords: reading comprehension, semantic schemas, discourse processes, force dynamics, ESP

Introduction

The general aim of this article is to show how an understanding of conceptual schemas from the perspective of cognitive linguistics can help facilitate non-native speaker understanding of scientific texts in English. Students from one of the Universidad Nacional Autónoma de México's high school systems have systematically pointed to vocabulary as their principal obstacle in reading comprehension activities in English. Obviously, strategies developed for accessing the meaning of unknown words must be situated in a global approach that begins analyzing the significance of the text from the perspective of the title, non-linguistic data such as format, typography and visual support from photos, illustrations and graphs correlated with the students' own knowledge of the world.[1] Whether or not the most important problem is the significance of difficult vocabulary items, understanding unknown words certainly constitutes one of the main challenges non-native speakers face when attempting to comprehend scientific texts in English.

Cognitive linguists like Talmy (1972) have been studying systematic relations in language between meaning and surface[2] expressions since the early seventies, with the purpose of locating meaning-form language patterns that seem to be pervasive across most languages. The conceptual content of the closed class (grammatical) forms of these patterns *determine the majority of the* structure *of the CR* (cognitive representation) (Talmy, 2000a: 21); these closed class forms are most often dedicated to representing a schema in idealized form (*Íbid.*: 26). The closed class forms analyzed by Talmy may be morphemes or lexemes (single or in combinations), but also include abstract grammatical categories and relations. It is the conceptual content of these abstract categories and relations that will be the focus of this article.

According to Lakoff (1987: xiv), precisely those patterns that occur in cognitive schemas are meaningful because they correlate with pre-conceptual structures in our daily experience:

[1] See Nutall (1996) for a treatment of global reading comprehension strategies.

[2] Talmy (2000b: 21) clarifies that in his writings he uses the word *surface* to indicate overt linguistic forms, and not as utilized in derivational theory).

> Thought is embodied, that is, the structures used to put together our conceptual systems grow out of bodily experience and make sense in terms of it; moreover, the core of our conceptual systems is directly grounded in perception, body movement, and experience of a physical and social character.

An important part of the message in each and every communication corresponds to one of a small number of underlying abstract conceptual schemas. This is one of the reasons why teachers should be aware of their existence and strategies for apprehending their role in the comprehension of difficult scientific texts.

Lakoff (1987: 272-275) describes the basic spatial schemas underlying speech events. These include the *container schema*: experiencing our bodies as both containers and things within containers; and the *center-periphery schema*: perceiving our bodies as having centers viewed as more important than peripheries (seen as dependent on the center and not vice versa). When we move, *there is a place we start from, a place we wind up at,* and *a direction* constituting the *source-path-goal schema*. Among others, there are *up-down, front-back* and *linear order schemas*. All these conceptual structures underlie both general conception and language (*Íbid.*: 272-275). Thus language patterns correspond to more general conceptual and pre-conceptual schemas pervasive in all aspects of general cognition.

It is the purpose of this article to describe strategies for tapping into these basic level schemas in an attempt to empower students for understanding scientific texts in English. It consolidates results from two different research projects[3]

[3] Meagher (1999, 2004) deals with the construction of significance. The general objective of the former is to develop a methodology for grasping meaning in order to apprehend participant concepts of the process of learning (which could also be applied to the study of other concepts), while the latter (among other objectives) pretends to examine how distinct semantic notions combine with the force dynamics system to give direction to discourse. Both projects seek to identify the underlying semantic schemas in discourse, often at a sublexical level. The first project compared expert and novice answers to the question: "What is the role of the teacher in the learning process?" Data was collected from a written questionnaire including multiple open and closed questions designed to discern conceptions of the learning process. Subjects were 27 novices and 25 experts from the UNAM high school system. The second project analyzed answers to several questions on networks and knowledge flow between academia and the private sector. Data was transcribed from oral interviews applied to 20 participants in joint projects (half from universities or research centers and half from

aimed at understanding the way meaning is constructed at discourse level and is a revised and extended version of the study presented for the 9th Latin American ESP Colloquium, held at the UNAM in 2005: Underlying thematic roles: a strategy for grasping meaning. The scientific problem motivating this research concerned the way semantic schemas relate to discourse structures. Research results verified the basic psychological reality of underlying conceptual structures and the relevance of their contribution to the construction of meaning. The scope of this article is limited to apprehending and applying underlying cognitive schemas in the comprehension of unknown vocabulary items, but this in no way suggests that strategies developed herein should be utilized at the expense of global learning. Rather, these strategies provide an excellent complement to established practice.

The second section of this article, **Cognitive tradition**, describes the goals and precepts of cognitive linguistics while ***Jackendoff and the basic conceptual schemas*** enters into detail describing relevant cognitive categories and the basic motion and location event from the perspective of Jackendoff's two tier theory of conceptual semantics. The following subsection, ***Talmy: an elaboration of causative schemas***, elaborates on the schemas corresponding to Jackendoff's action tier via Talmy's analysis of causation, an approach compatible with Jackendoff's examination of the fundamental motion and location event. The third subsection, ***Basic conceptual schemas in scientific discourse***, exemplifies both Jackendoff's and Talmy's categories and schemas with examples from an article on "Probing the Geodynamo" from the *Scientific American*. The third section, **Applications in reading comprehension courses at a high school level**, simplifies the schemas described in **Cognitive tradition** and illustrates how these might be used to help students in grasping the meaning of unknown vocabulary items which could complement a global approach to reading comprehension. The conclusions show that familiarizing students with basic cognitive schemas aids them in apprehending the meaning of unknown vocabulary items in scientific texts in English.

industrial research centers or private companies). Questions included the following: In your opinion, are there any obstacles that limit knowledge flow between academia and the private sector? Can you describe the most important ones? In your opinion, what is the role of academia in the process of developing innovative technology? What is the role of private companies?

Cognitive tradition

Research is situated within the cognitive linguistic tradition particularly from the perspective of Talmy's cognitive semantics. This approach focuses on *how language structures conceptual content* (Talmy, 2000a: 2). It deals with conceptual categories like space, time, scenes, events, entities, motion, location, force and causation and also examines cognitive phenomena like attention, perspective, volition, intention, expectation and affect (*Íbid*.: 3). The nature of event structure was central to Talmy's concerns from the time of his doctoral dissertation (1972), when he elucidated the basic motion event as either motion or location in possible combination with a co-event related to a larger motion situation. Talmy (1991) further elaborates this structure as a framing event to which a co-event relates, now within a larger macro-event structure.

Another important aspect of cognitive semantics is its interest in the relationship between psychological reality and linguistic structure. At the same time, it considers how a detailed analysis of the way language expresses cognitive structure contributes to knowledge on the properties of these very structures. Thus, *for cognitive semantics, the main object of study itself is qualitative mental phenomena as they exist in awareness* (*Íbid.*: 4). From this perspective Talmy (*Ídem*) affirms that cognitive semantics corresponds to the *phenomenology of conceptual content and its structure in language.* And lastly, it is imperative to signal his attempts to *ascertain the universal properties of conceptual organization in language* (*Íbid.*: 15) as depicted in a global integrated system of conceptual structuring: schematic systems of configurational structure, location of perspective point, distribution of attention and force dynamics.

Although Jackendoff (1990: 7) comes from the generative tradition, his object of study (*the form of knowledge that ordinary language calls concepts, thoughts or ideas and how such knowledge is expressed in the syntax of natural language*) is compatible with much of cognitive semantics. Jackendoff himself (2002: xv, xvi) admits that he diverges from standard generative theory when he says that *lexical items are of heterogeneous sizes, from affixes to idioms and more abstract structures.* He goes on to state:

> This reconceptualization of the lexicon leads to striking consequences for linguistic theory, in particular breaking down some of the traditional distinction between

> lexical items and rules of grammar. It also leads to a reconsideration of the formal character of language learning (*Ídem*).

There is much in what he is saying that coincides with the cognitive approach that meaning can be viewed as a continuum ranging from lexical items to grammatical structure. He criticizes the prototypical generative attitude towards semantics advocating a more universal approach:

> A glaring lacuna in most approaches to generative grammar has been the absence of a theory of semantics of any sophistication. Part III [of *Foundations of language*] is devoted to working out the foundations of semantics in a manner compatible with the goals of generative linguistics, incorporating insofar as possible (largely incompatible) approaches, including traditional philosophy of language, logic and formal semantics, lexical semantics of various stripes, cognitive grammar, psycholinguistic and neurolinguistic approaches and my own conceptual semantics and related work (*Ídem*).

Though Jackendoff may have maintained the goals of generative grammar, he deviates from that position regarding methodology. His empirical research deals with semantics and its relation to syntax. What is most interesting is his elaboration of basic ontological categories applying the logic of functions and arguments for propositional structures:

> […] it is argued that the essential units of conceptual structure are *conceptual constituents*, each of which belongs to one of a small set of major ontological categories (or conceptual "parts of speech") such as Thing, Event, State, Action, Place, Path, Property, and Amount (Jackendoff, 1990: 22).

As mentioned earlier, this approach correlates with research in the field of discourse analysis from a cognitive perspective. The most important result of this research was the confirmation of the fundamental psychological reality of underlying conceptual structures and the importance of their contributions to the construction of meaning. The basic criteria for both Talmy and Jackendoff in their quest for event structures are introspective. According to Talmy (2000a: 5), "the findings resulting from introspection must be correlated with those resulting from other methodologies. Such other methodologies include the analysis of introspective reports by others, the analysis of discourse and corpora… and the observational and experimental techniques of psycholinguistics", to mention a few. Since Meagher (1999, 2004) analyzed authentic *corpora* demonstrating discourse could be coded in the terms delimited by Jackendoff and Talmy, results validated both their conceptual schemas and categories. Event structures are motivated by the way the individual perceives and executes physical motion and location on the spatial plane. The language analyzed in the above mentioned research transcends physical motion to study metaphoric mapping permitting these schemas to be expressed in multiple domains, such as: temporal, possessive, existential, identificational, and circumstantial. Nevertheless, it is easier to apply these schemas to scientific discourse which tends to describe physical motion and location. In addition, science students have a greater need to read authentic texts in English as an integral part of their course materials. For these reasons, this article focuses on applications of an apprehension of basic ontological categories and event structures in scientific discourse.

Over 25 years experience teaching reading comprehension has proven that there is not always an equivalence between students' ability at speaking and writing in L2 and their capacity for handling the cognitive tasks implicit in reading comprehension. There is still a lot of debate on whether cognitive ability is an inherited or acquired asset. Nevertheless, in my opinion, an approach to cognitive schemas as an integral part of reading comprehension strategies permits all students to improve their understanding of L2 texts, albeit certain students achieve it more quickly than others. It is the potential of understanding how underlying schemas contribute to the construction of meaning that has led me to undertake the subsequent analysis and apply an appreciation of these schemas in the academic classroom. The following section describes Jackendoff's basic ontological categories in motion and location schemas.

Jackendoff and the basic conceptual schemas

Jackendoff (1983: 56) believes "the total set of ontological categories must be universal: it constitutes one basic dimension along which humans can organize their experience" (*Íbid.*: 56). He tests the validity of his ontological categories via pragmatic anaphora, that is to say that a speaker pointing can designate the corresponding referent (*Íbid.*: 48, 49). See Figure 1 for some of his examples.

Figure 1. Ontological categories and pragmatic anaphora

Ontological category	Pragmatic anaphora
Thing	I bought *that* yesterday (pointing).[4]
Place	Your coat is *here* (pointing) and your hat is *there* (pointing).
Path	He went *that away* (pointing).
Action	Can you do *that*? (pointing). Can you do *this* (demonstrating).

Jackendoff (*Íbid.*: 53) goes on to further validate his categories demonstrating how each permits the formation of a *wh*-question with possible reduced answers. See Figure 2 for some of his examples.

Figure 2. Ontological categories and *wh*-questions

Ontological category	Wh-question	Reduced answers
Thing	What did you buy?	A fish.
Place	Where is my coat?	In the bathtub.
Path	Where did they go?	Into the bathtub.
Action	What did you do?	Go to the store.

Inspired by developments of tier theory in phonology, Jackendoff (1990: 125-27) postulates these structures as part of a two-tier semantic theory. The first tier deals with how entities move or are located on the spatial plane. The way this works out has many similarities to the basic event structures elaborated by Talmy (1972) in that events correspond either to motion or location schemas.[5] The second tier is the action tier and consists of interactions between agent and patient (affected entity). He distinguishes two interactive entities: actor (agent)[6] and pa-

[4] *That* is a substitute for a thing (entity), *i.e.* a dress. *Here*, *there* and *that away* are substitutes for prepositional phrases. However, *here* and *there* refer to places like *in the corner* or *under the table*, whereas *that away* refers to a trajectory or path over which motion occurs like *into the garden, to school* or *towards the center of the city*. *That* and *this* can be substituted for by a verb phrase like *jump through a hoop* or *stand on your head.* They refer to actions.

[5] This is possible due to the formulation of parallel domains, such as: spatial, temporal, possessive, identificational, existential and circumstancial, for example. Talmy's work precedes Jackendoff's, but in this case I feel the manner in which the latter presents his analysis is more suitable for the purpose of facilitating the apprehension of unknown vocabulary items.

[6] Actors carry out actions, while the actions of agents affect patients.

tient. The test for actor consists in answers to "What NP did was…", the test for agent coincides with answers to the question "What Y did to the noun phrase was…", while the test for patient corresponds moreover to answers to "What happened to NP was…?", Y being the agent and the noun phrase, the patient (Jackendoff, 1990: 125,126). See Figure 3.

Figure 3. Test for agent and patient

Thematic role	Example	Test question
Actor NP	*Bill* ran down hill.	What *NP* did was? (What *Bill* did was *Bill* ran down hill.)
Agent X	*Sue* hit Fred.	What *X* did to NP was? (What *Sue* did to Fred was hit him.)
Patient NP	Sue hit *Fred*.	What happened to *NP* was? (What happened to *Fred* was Sue hit *him*.)

Jackendoff recognizes the fundamental importance of causation with the interaction agent/patient corresponding to the schemas in his action tier. Nevertheless, I have felt it necessary to elaborate on his intuitions from the perspective of Talmy's theories on force dynamics and causative schemas in the following section.

Talmy: an elaboration of causative schemas

This section expands Jackendoff's causative schemas outlining a number of force dynamic patterns developed by Talmy as a generalization of causation (1985) for several reasons: Talmy's analysis of causation (Jackendoff's action tier) is much more sophisticated and complete, Jackendoff's work on the action tier was motivated by Talmy's more complete analysis, and I believe the intricacies of his interaction patterns are quite pertinent for advanced students facing the challenge of reading scientific texts in English as a foreign language. It is pertinent to point out, nevertheless, that both approaches to causation are compatible, Talmy's analysis just being more complete.

As stated previously, force dynamics is one of the four integrated systems that organize the conceptual content of language. Force dynamics occurs when there is an interaction between two forces. Language marks this interaction at the level of discourse, lexis and/or syntax, representing forces with only two opposing tendencies (not necessarily so in modern physics). Inspired by muscular interaction Talmy (2000[a]: 413-415) refers to the forces in interaction as *agonist* (the focal force) and *antagonist* (the opposing force). From a linguistic point of view three factors are taken into account: the intrinsic tendency of an entity (rest/motion), the relative strength of the entities in interaction, and the result of the force dynamics interaction (rest/motion). These force dynamic interactions may be *steady state* (occurring over a period of time) or *shifting* (beginning/ending).

Talmy's classic example (*Íbid*.: 416):

(1) The ball kept rolling despite the stiff grass

exemplifies *steady state* force dynamics. The *ball* is the agonist with an intrinsic tendency toward motion (if on an inclined slope) while the *stiff grass* is the antagonist, exerting a pressure toward rest. The relative strength of the *ball* is greater than that of the *grass* and the end result is continued motion. *Despite* always denotes a stronger focal force or agonist. In contrast, his example (*Íbid.*: 418):

(2) The ball's hitting it made the lamp topple from the table

corresponds to a shifting pattern. In this example *the lamp* is the focal figure (agonist) with an intrinsic tendency towards rest and the *ball* the antagonist with an intrinsic tendency towards causing motion, especially when slamming into another entity —with motion as a result when *the lamp topples from the table*. In the former, the motion of the focal force is constant while in the latter there is a change of state from rest to motion.

A fundamental point for consideration is the interaction between aspectual and causative types. Talmy (*Íbid.*: 78) distinguished *stative* (being in a state), *inchoative* (entering a state) and *agentative* (putting in a state). Also important is the concept of *exiting a state* or *removing from a state* (*Íbid.*: 86). In the case of (1) the force dynamic interaction is *stative* as it describes the *ball's* being in a state despite opposition, while in the case of (2), the interaction is *agentative* as the *ball corresponds to the instrument* (acting as *agent*) that puts the focal figure into a new state: motion. Given the importance of the phenomena of causation for the diffusion of scientific knowledge, all these distinctions are most relevant.

In his analysis of lexicalization patterns of event structures Talmy maps out different focuses on the causative event. The number of distinct types of causation lexicalized in verbs is much greater than the usually recognized two-way distinction between *noncausative* and *causative* (Talmy, 2000b: 69, 70). Some verbs express only one causative type while others may signify a range of types. Possibilities include: autonomous event (non-causative), resulting-event causation, causing-event causation, instrument causation, author causation (*i.e.* with result unintended), agent causation (*i.e.* with result intended), under-goer situation (not causative), self-agentative causation, and inductive causation (caused agency). His analysis of the different uses lexicalized for the English verbs *die, kill* and *murder* is most illustrative (*Íbid.*: 73). See Figure 4.

Figure 4. Causative meaning incorporated in the verb root

Category	Example	Die	Kill	Murder
Autonomous event (not causative)	He underwent death.	He died	*He killed	*He murdered
Resulting event causation	He died *from a car hitting him.*	He died.	*He killed	*He murdered
Causing event causation	*A car's hitting him* killed him.	*died him	killed him	*murdered him
Instrument causation	*A car* killed him (in hitting him).	*died him	killed him	*murdered him
Author causation (*i.e.* without intention)	*She unintentionally* killed him.	*died him	killed him	*murdered him
Agent causation (*i.e.* with result intended)	She killed/murdered him *in order to be rid of him.*	*She died him	She killed him	She murdered him
Self-agentive causation[7]	He killed himself *by internal will.*	*He died	*He killed	*He murdered
Induced causation[8] (caused agency)	She induced him to kill others.	*He died him	*He killed him	*He murdered him

The following section exemplifies these categories in detail using examples from scientific discourse.

Basic conceptual schemas in scientific discourse

A global approach[9] to the article "Probing the geodynamo" by Glaztzmaier & Olson (2005) permits students to discern that this article describes the three conditions necessary for generating a planet's magnetic field (a large volume of electrically conducting fluid, a supply of energy to move the fluid and rotation) and also to determine its focus on an analysis of the reasons why the polarity of the earth's magnetic field occasionally reverses. However, it leaves them at a loss

[7] *I walked to the store.*

[8] *I sent him to the store.*

[9] An analysis of title, the content text in large print, visual support, typography and legends at the bottoms of photos and illustrations, among others.

as to the meaning of many diverse relevant lexical items. This section attempts to demonstrate equivalences between Jackendoff's and Talmy's basic ontological categories and conceptual schemas and specific content from the above mentioned article pointing out certain pedagogical applications and precautions, but it is the following section that will simplify these concepts adequately for application in reading comprehension courses at high school level.

Both researcher and ESP student can easily locate several different kinds of *entities* repeated frequently throughout the article. On the one hand there are nouns fulfilling a quantifier function like *a large volume* or *a supply,* and on the other, qualitative entities related to the layers of the earth's interior, such as *the inner core, the outer core, the mantle, the crust,* entities incorporating physical and/or chemical properties, like *the iron-rich liquid core, magnetic field, turbulence pattern, thermal convection, fluid motion, molten core, liquid iron, crystals, dense chemical compounds* or those directly (or indirectly) related to computer simulations, including *computer models, satellite maps and laboratory convection experiments* to mention a few categories. Spanish speaking students should be made aware of the differences in word order between their language and English where the entity (noun) is at the end of the NP. Several grammatical clues may help them locate the NP: the presence of articles, sentence position or the fact of their coming before a verb and/or after prepositions. Students should learn that in a series of nouns (not separated by commas) the last noun functions as an entity and the others fulfill an attributive function describing this entity.

Using Jackendoff's conventions for describing the basic ontological categories (1990: 43), the *place-function* structure can be elaborated as a place-function plus an argument belonging to the category *thing* which I prefer to call *entity*. The argument serves as a spatial reference point for defining a region. See Figure 5.

Figure 5. Place function[10]

$$[_{\text{Place}}\text{IN}\ ([_{\text{Entity}}\ \text{THE CENTER OF THE EARTH}])]$$

[10] The corresponding function argument structures have been included in this section for benefit of teachers and researchers. However, I would not recommend their use with students. See the following section for a simplification applicable at high school level.

In this example the place-function *in* combines with the argument *the center of the earth* to define a region.

The function *path* (*Íbid*.: 44) maps a place into a related trajectory. The difference between the two is fundamental as the place-function corresponds to the conceptual category location while the path-function implies movement on a spatial (or metaphorical) plane. The prototypical path-function in English is the proposition *to*. Others correspond to the categories *from, toward, away from* and *via.* See Figure 6.

Figure 6. Path-function

$$[_{\text{Path}}\text{ALONG}\ ([_{\text{Entity}}\ \text{HELICAL PATHS}])]$$

In this case the path-function *along* (corresponding to Jackendoff's conceptual *via*) takes the entity *helical paths* as its argument. In this example both lexis and syntax combine to define a trajectory. The difference between these two function-argument structures (although both correspond to the category *where*) is relevant as a strategy for discovering meaning. The verb coming before a *path-function* must express physical or metaphorical motion, while the one before a *place-function* corresponds to physical or metaphorical location. An understanding of this opposition is fundamental for students as most verbs convey a schematic meaning of either physical (or metaphorical) motion or location. An adequate appraisal of a fairly small number of prepositions can thus aid students in determining to which of these two categories the verb pertains and thereby in deciphering an important part of the verbs' conceptual content.

The conceptual category *event* can be elaborated either as motion along a path or stasis over time:

(3) The fluid reaches the top of the core.[11]

[11] Glatzmaier & Olson (2005: 34). The complete sentence is *When the fluid reaches the top of the core, it loses some of its heat in the overlying mantel* and corresponds to Talmy's category: causing event causation.

The event category is illustrated in Figure 7, that elaborates the function-argument structure for (3).

Figure 7. Event-function

$[_{Event}$GO $([_{Entity}$ FLUID$],[_{Path}$TO$([_{Place}$ THE TOP OF THE CORE$])])]$

In this example the event-function *go* expresses the motion of its first argument (subject), the entity *fluid.* The second argument, the prepositional phrase *to the top of the core*, is itself composite consisting of the path-function *to* and the place *the top of the core,* in this case the place-function being stated lexically as *the top.*

From one point of view Langacker (1987) would disagree with this analysis as he affirms that different superficial structures express distinct meanings, and I would agree with this view. Nevertheless, the usefulness of this perspective for ESP students is indisputable. In practice Jackendoff versus Langacker on this point is just a question of timing. As a first approach, it is imperative that students recognize that the meaning of *reaches* in this speech event corresponds to the movement schema. Later on, at the proper time, it would be important for the student to learn a more precise meaning for *reaches*. At that time an apprehension of the schematic meaning will aid him in recognizing the appropriate precise meaning from an English–English dictionary, as well as facilitate his deciding if the term in a bilingual dictionary is adequate for the particular context in question.

Jackendoff elaborates two different kinds of *causative-functions*. In the first case an entity is the causal agent, while, in the second, an event causes another event. In the next example,

(4) Coriolis forces deflect the up-welling fluid along helical paths[12]

the entity *Coriolis forces* is conceptualized as the causal instrument (acting as agent) which therefore corresponds to Talmy's category instrument or agent causation depending on whether the reader views Coriolis forces as a personified agent or an instrument of nature (both being conceptually possible). See Figure 8.

[12] *Ídem.*

Figure 8. Entity as causal agent in cause-function structure

$$\left[_{\text{Event}}\ \text{CAUSE}\ \left(\left[_{\text{Entity}}\ \begin{matrix}\text{CORIOLIS}\\ \text{FORCES}\end{matrix}\right], \left[_{\text{Event}}\ \text{GO}\ \left(\left[_{\text{Entity}}\ \begin{matrix}\text{UP-}\\ \text{WELLING}\\ \text{FLUID}\end{matrix}\right], \left[_{\text{Path}}\ \text{ALONG}\ \left(\left[\begin{matrix}\text{HELICAL}\\ \text{PATHS}\end{matrix}\right]\right)\right]\right)\right]\right)\right]$$

In this example the first argument *Coriolis forces* causes the second argument *the up-welling fluid* to map onto the trajectory *along helical paths*. (As stated earlier, the presence of a path implies motion).

It is important to point out several characteristics in this causative schema. First of all, there is an agent (or instrument) that does something: *Coriolis forces.* There is an affected entity (patient) that undergoes a change to a new state: *the up-welling fluid* begins to traverse a *helical path.* The agent is the energy source, and the patient the energy goal: there is a transfer of energy from *forces* to *fluid.* The onset of causation implies change, signaled by the lexical meaning of the verb *deflects*: turn from a true course or straight line (Stein, 1967: 379). In this example the change is from path_1 (*up*) to path_2 (*helical*), that is to say that the fluid which was *welling up* begins to move in a *helical* or spiral manner. Thus the interaction corresponds to the category *shifting force dynamics*. Combining Talmy's intuitions with Jackendoff's function-argument structures, we have a powerful tool for aiding students to unravel the meaning of causative structures.[13]

In the following example,

(5) heat escaping from the upper core causes the solid inner core to grow[14]

the event *heat escaping from the upper core* (E_1) causes the second event: the growth of the solid inner core (E_2). See Figure 9.

Figure 9. Event as causal agent in cause-function structure

$$\left[_{\text{Event}}\text{CAUSE}\left[_{\text{Event}}\text{GO}\left(\left[\text{HEAT}\right], \left[\text{FROM}\left(\left[\begin{matrix}\text{UPPER}\\ \text{CORE}\end{matrix}\right]\right)\right], \left[\text{GO}\left(\left[\begin{matrix}\text{SOLID INNER}\\ \text{CORE}\end{matrix}\right], \left[\begin{matrix}\text{FROM}\left(\left[\text{LESS}\right]\right)\\ \text{TO}\left(\left[\text{MORE}\right]\right)\end{matrix}\right]\right)\right]\right)\right]\right]$$

[13] See Lakoff (1987: 54) for another in depth cognitive portrayal of the causative schema.

[14] Glatzmaier & Olson (2005: 34).

In this example change, is implied by the lexical meaning of *grow*: to increase in size (Guralnik, 1970: 619). The agent[15] (the energy source) is the event: *heat escaping from the upper core.* In this case *the solid inner core* is the affected entity (the energy goal) that undergoes a change to a new state: a larger size, thus corresponding to another shifting pattern with agent (or instrument) causation.[16]

From this perspective according to Jackendoff (1990: 47), agents and patients are structural positions in conceptual configurations. They are not primitives of semantic theory, but rather *relational notions defined structurally over conceptual structure.* From a pedagogical point of view the conceptualization of schemas as such facilitates an analysis with multiple applications for ESP teachers and students. The following section suggests multiple ways facilitating students' understanding of conceptual categories and schemas may aid their apprehension of the meaning (or at least part of the meaning) of unknown vocabulary items.

Applications in reading comprehension courses at a high school level

Reading comprehension strategies developed in this section have been based on two conceptual approaches to the construction of meaning: on the one hand this perspective closely follows Jackendoff's methodology for an analysis of the spatial scene (also compatible with Talmy) and on the other, it uses Talmy's fine point intuitions concerning causation to elaborate on Jackendoff's examination of the action schema. The importance of apprehending underlying schemas stems from the fact that language patterns conform to more general conceptual and pre-conceptual schemas based on everyday experience as described by Lakoff. An important part of every communication is structured by one of a limited variety of abstract schemas. As soon as the student discovers to which of these conceptual schemas the relevant discourse pertains, he has deciphered an important part of the message whether or not he understands all the vocabulary employed. He or she can then use the schema to grasp unknown meanings. When necessary the student can then utilize the schema to decide which of several dictionary mean-

[15] Like *Coriolis forces*, *heat* may either be conceived of as a personified agent or as an instrument of nature. In many situations, however, there is a definite agent and also an instrument used by the agent to bring about a change.

[16] In Meagher (1999: 20-40), states can also be both causal agents and the result of causal interactions.

ings are appropriate for a given context. Depending on the relevance of the fragment under analysis, the schematic meaning might even be enough for him or her to continue reading without further consultation. This section shows how schemas might be used in an actual classroom. As declared above, this article limits its scope to an elucidation of cognitive strategies for understanding the meaning of unknown vocabulary items. This should not be attempted without students first carrying out a global analysis as data from a superficial examination of the text as a whole will give them information necessary to decipher specific details.

In the National Preparatory School (ENP) of the National University of Mexico (UNAM) reading comprehension courses are taught by area as follows (area one: physics and mathematics; area two: biology and chemistry; area three: law, economics and administration, and area four: humanities). The applications outlined in this part of the article are especially pertinent for areas one, two and three.[17] As mentioned above, one of the most difficult challenges facing Spanish speakers while reading scientific texts in English is the problem of deciphering the meaning of unknown vocabulary items, usually without any Latin roots. Underlying conceptual schemas can be of great assistance in permitting students to ascertain the function and thus an important part of the meaning of the lexemes in cognitive schemas. Currently, students recognize three distinct patterns or schemas:

1. Actor Action Affected Entity Where When (active voice)[18]
2. Affected Entity Action BY Actor Where When (passive voice)
3. X = Y (referential equations and designation of properties)

The first two usually correspond to physical or metaphorical movement on a spatial plane, and the last, to localization.[19] As you can see, the theoretical

[17] Depending on student preferences, I often teach area four more as a literature or performance course rather than focusing on ESP strategies.

[18] When necessary, the patterns should be expanded to include categories like *how* and *why* or other pertinent circumstantial classes. However, *where* and *when* seem to be the most basic of these.

[19] In the close to 10 years I have been experimenting with these cognitive schemas in reading comprehension classes, their significance has corresponded to a great part of the meaning in each of the sentences analyzed from a discourse perspective. Together with other circumstantial categories they provide a classification that allows students to recognize the functions of the basic parts of any communication.

framework corresponding to these conceptual schemas has been reduced to an absolute minimum and presented with terms students are likely to apprehend. It is necessary for students to recognize which part of the schema corresponds to the word's function. The schemas are underlying semantic patterns, but knowledge of certain grammatical concepts is essential for the task. For example, the presence of an article announces the presence of a noun (entity). At this point for Spanish speakers an understanding of the comparative word order of noun phrases is imperative.[20] As for other grammatical concepts, it is probably easier for intermediate students to recognize the pattern for passive voice (a form of *to be* plus past participle): the absence of a form of this auxiliary eliminates this option. For advanced students the task may be devised from either the passive or the active perspective. At the same time students need to recognize that forms of the verb *to be* by themselves indicate a high probability of referential equations or designation of properties ($x = y$, with y expressed as either an entity or a quality). Students must also recognize common punctuation marks that express the same function. Basically x = y corresponds to a classification or categorical statement. Strictly speaking classification statements correspond to Lakoff's *container schema* as entities or qualities are physically or metaphorically located in specific mental spaces. Nevertheless, it seems to be easier for students to understand referential equations and attribution as examples of the simplified schema: x = y.

Once students can recognize the underlying schema to which a specific sentence corresponds and identify the function of the unknown word, the probability of their guessing the approximate meaning in context of this lexeme is greatly enhanced. Curiously enough students at the ENP are better at guessing the meaning of unknown words than at recognizing that a known vocabulary item is being used in an unfamiliar manner. Let us look at some specific examples from the article on the *geodynamo* (Glatzmaier & Olson, 2005: 34):

(6) A large volume of electrically conducting fluid, the iron-rich liquid outer core of the earth, is the first of these conditions. This critical layer surrounds a solid inner core…

[20] This is probably the single most important grammatical concept Spanish speakers must grasp to understand academic texts in English.

See Figure 10 (I have included the function-argument structure corresponding to this schema, but for high schools students I limit theory to $x = y$. It is very useful for them, however, to recognize whether y corresponds to an entity or a quality.)

Figure 10. Referential equations $\left[_{State} BE_{Identity} \left(\left[_{Entity} X \right], \left[_{Place} AT_{Identity} \left(\left[_{Entity} Y \right] \right) \right] \right) \right]$

X	=	Y
A large volume of electrically conducting fluid	, ,	the iron-rich liquid outer core of the earth
A large volume of electrically conducting fluid	Is	the first of these conditions

A student that recognizes the chain of referential identity present in this text has accomplished an important part of understanding its meaning. He should be able to equate *a large volume of electrically conducting fluid, the iron-rich liquid outer core,* and *the first of these conditions.* This acquires additional importance if the student ignores, or is uncertain about, the meaning of vocabulary items. If he understands the concepts corresponding to *x*, he may be able to determine the meaning corresponding to ***y*** and vice versa.

The same kinds of strategies are just as useful in unraveling the identity of the referent for the demonstrative adjective *this* in (6). Here the student needs to master two skills: discovering the identity between *this critical layer* and *the iron-rich liquid outer core,* and also recognizing the function of *this critical layer*: first argument of the state-function expressing extension in relation to a spatial reference point, *a solid inner core.* For the student, this knowledge should take the form of *entity*$_1$ *is located around entity*$_2$: *The critical layer* is located around *a solid inner core*.

Now look at some examples where *y* designates a property (*Ídem*):

(7) By the 1940's physicists had recognized that *three basic conditions are necessary* for generating any planet's magnetic field… *Core temperatures are similarly extreme* —about 5,000 degrees Celsius, similar to the temperature at the surface of the sun.

In Figure 11 we have two examples of properties. Conceptually specific entities are located at these properties in the *identificational* field. Students should recognize the correspondence between entities and qualities as well as their markers, in both cases above, the verb: *are*.

Figure 11. Properties[21] $\left[_{State} BE_{Identity} \left(\left[_{Entity} X\right], \left[_{Place} AT_{Identity} \left(\left[_{Property} Y\right] \right) \right] \right)\right]$

X	=	Y
…three basic conditions	are	necessary
Core temperatures	are	…extreme

Once students have mastered relationships between entities and entities or qualities, they can move on to the prototypical action schema: *actor, action, affected entity*. See the next example:

(8) The earth's *rotation…deflects* rising *fluids* inside the earth's core the same way *it twists* ocean *currents and* tropical *storms* into…spirals…

Figure 12. Actor action affected entity

Actor	Action	Affected Entity	Where	How (manner)
The earth's rotation	deflects	rising fluids	inside the earth's core	the same way
It (The earth's rotation)	twists	ocean currents and tropical storms	into the familiar spirals	

The student's initial task is to recognize the correspondence between the entities and actions in Figure 12 and the schema: *actor*, *action, affected entity*. The easiest approach for intermediate (or if relevant, beginning) students is a process of elimination. In these examples there is no form of the verb *to be*, either by itself or combined with a past participle. Nor within each example is there any punctuation mark indicating a referential equation ($x = y$). Therefore, most likely, the underlying schema does not correspond to $x = y$ or *affected entity, action*, but rather to *actor, action, affected entity*. The correlation with this schema gives the student a great part of the meaning. Let us suppose he does not understand *twists* in the second example: *it twists ocean currents and tropical storms into spirals*. First it is imperative to equate *it* from the second and *the earth's rotation* from the first causative schemas as entities with referential identity and next identify *the earth's rotation* as the actor of the action: *twists into spirals.* Then the student has to dis-

[21] Again the entire formula has been included, but presentation of the schema for students is limited to x = y.

cover what action the agent,[22] *the earth's rotation,* can do to the affected entity, *ocean currents and tropical storms*, regarding the path *into spirals*. This method of analysis narrows the field considerably; and once the student has acquired enough practice, permits him to deduce a sufficiently approximate meaning to continue on reading without loosing track of the gist and/or important secondary concepts.

Equally, a superficial examination of (9) and (10) analyzed in Figure 13 should permit students to deduce that they correspond to the schema: *affected entity, action*.

(9) The cores high temperatures are the result of *heat that was trapped* at the center of the earth during its formation (*Ídem*).
(10) Sometimes the bending is *caused by* the rising *fluid* in an up-welling (*Íbid*.: 36).

Figure 13. Affected entity action

Affected entity	Action	By actor	Where	When
…heat That	was trapped		at the center of the earth	during its formation.
…the bending	is caused	by the rising fluid	in an upwelling	Sometimes

The presence of forms of *to be* (*was* and *is*) plus the past participles *trapped* and *caused* signals the passive voice. Therefore the student knows the first entity was affected by the action in question. In the event that the passive voice action is followed by the preposition *by* plus an entity, this entity is an agent (or instrument with an agentative function) as in (10): *the rising fluid* is the agent that caused *the bending*. Let us return to the complete context of (9).

Again a correct correlation between schemas and functions permits students to perceive that *trapped* is the action that happened to the affected entity *heat* at the location *the center of the earth* at the time *during its formation.* This can aid in solving two pertinent problems: the approximate meaning of *trapped* and the referent of *that*. Also students can learn to recognize the $x = y$ schema underlying: ***The core's high temperatures*** **are** ***the result of heat*** *that was trapped at the*

[22] Again it is possible to conceptualize *the earth's rotation* either as a personified agent or an instrument of nature.

center of the earth during its formation, where ***y*** contains a clause that expands the NP: *the result of heat* and where *are* marks the referential equation.

The full text of (10) reads as follows (*Ídem*):

(11) These turbulent fluid motions can bend and twist the toroidal field lines into loops called poloidal fields, which have a north-south orientation. Sometimes *the bending is caused by the rising fluid in an upwelling*.

In this case, the student must recognize the NP: *these turbulent fluid* ***motions*** placed at the beginning of the sentence and ending with the noun, *motions* (the last word in the phrase before the verb phrase *can bend*). A second strategic deduction could be to notice that the agent *these turbulent fluid motions* has the potential to carry out the actions: *bend* and *twist* on the affected entity, *field lines.* Since *twist* was already identified as the action *the earth's rotation* performed on the affected entity *ocean currents* and *tropical storms* regarding the path *into spirals,* it is possible for the student to deduce that *bend* is a similar action and that *the bending* is a nominalization that makes an entity out of an action. Even when these strategies do not permit students to deduce the precise meaning of the lexeme in question, they are fundamental in deciding which of the many dictionary meanings is adequate in a specific context.

As we stated above, the force dynamics system was developed by Talmy as a generalization of causation. It is lexicalized as an interaction between two forces. The force interaction can be expressed lexically, syntactically or through discourse context. Science students can begin to build a vocabulary of lexical items with inherent force dynamic properties. Sometimes the force dynamic interaction is expressed explicitly as a causative schema with lexical items like *cause* or *result* as in the texts corresponding to 5, 9 and 10, respectively. At other times, the intrinsic meaning of the vocabulary contains force dynamic implications. Let us look at some prototypical examples from this article:

(12) The earth's rotation simultaneously *drives* helical circulation of the molten fluid.

The *Webster's new world dictionary of the American language* defines *drive* as *to force to go* (Guralnik, 1970: 427). The student can discern that *the earth's* *rotation* is an agent that affects the NP: *helical circulation of the molten fluid* in a force dynamic manner. The same is true of *pushes* in the following text:

(13) Fluid rising through the molten outer core *pushes* upward on roughly horizontal magnetic field lines within the core.

In this case *pushes* is defined as *to exert pressure or force against, esp. so as to move* (*Íbid.*: 1155). Here *fluid* is the agent acting on the affected entity *horizontal magnetic field lines.* When the science student encounters these lexically force dynamic lexemes he knows the agent causes a change in the affected entity. In (5) the *earth's rotation* causes the *helical* (spiral) motion of the *molten fluid*, while in (6) *fluid* exerts an upward pressure on *roughly horizontal magnetic field lines* causing upward motion. Force dynamic structures do not always induce movement, but quite the contrary as in (14) below:

(14) *Strong* electric currents in the core *prevent* direct measurements of the magnetic field there.

Prevent is defined as *to keep from happening; make impossible by prior action* (*Íbid.*: 1127). In this case the action of *strong electric currents* is the force that acts as an obstacle for the affected entity *direct measurements.* As is obvious in this causative structure, action is impeded. In addition notice that *strong* is another lexeme with force dynamic implications, defined as *accompanied or delivered by great physical or mechanical power or force* by the *Random House dictionary of the English language* (Stein, 1967: 1409).

Force dynamic interactions are often marked syntactically. In this segment of (6), Fluid ris*ing* through the molten outer core…, the *–ing* form of the present participle signals active voice, indicating that *fluid* is an actor carrying out the action *rising* (and not the entity affected by this action).[23] On the contrary an *–ed* morpheme in the past participle *called* as in (8) indicates passive voice describing an affected entity:

(15) A satellite *called* Magsat…

[23] The same is true for the *ing* morpheme in the text corresponding to Figure 9: *heat* is the actor that carries out the action *escaping*.

In this case, the entity *satellite* did not carry out, but was affected by the action *called*. The same holds obviously for the past participles (*trapped* and *caused*) corresponding to passive voice in (9) and (10). *Heat* is the entity affected by the action *trap* and *the bending* that affected by the action *cause.* By the same token in (10) the preposition *by* points out the agent: *the rising fluid* that carried out the action *caused* affecting the entity *the bending.* Here the subject of a sentence in passive voice is the affected entity, not the agent. The agent is the object of the prepositional phrase introduced with the preposition *by*. These kinds of grammatical clues to the functions of entities in causative schemas are most useful for students reading scientific texts in English as a foreign language.

Conjunctions also provide evidence indicating which part of the causative schema is being expressed by particular clauses. *Because* introduces the cause in a cause-effect schema. See (16) below:

(16) Compass needles point to the earth's north geographic pole *because* the dipole's[24] south magnetic pole lies near it.

Because introduces the clause that corresponds to the cause: *the dipole's south magnetic pole lies near it*, while the independent clause expresses the effect: *compass needles point to the earth's north geographic pole*. The position of *because* can vary, but the cause always follows this conjunction.[25]

On the other hand, the conjunction *therefore* and the adverb *thereby* introduce the effect. See (17) below:

(17) Each twist packs more lines of force into the core, *thereby* increasing the energy in the magnetic field.

In this example the independent clause expresses the cause: *each twist packs more lines of force into the core*, and the adverb *thereby* introduces the effect: *increasing the energy in the magnetic field.* These grammatical clues are most helpful for students trying to distinguish cause from effect.

[24] The *dipole* is the magnetic field on the earth's surface.

[25] This sentence could have read: Because the dipole's south magnetic pole lies near it, compass needles point to the earth's north geographic pole. Nevertheless, *because* continues to introduce the cause.

Another important distinction introduced by Talmy refers to the outcome of the force dynamics interaction. Both the conjunction *although* and the preposition *despite* introduce an event/agent that does not succeed in bringing about a change. See (1) and (18) below:

(18) *Although* the geodynamo produces a very intense magnetic field, only about 1 percent of the field's magnetic energy extends outside the core.

An important point in this article on the geodynamo stems from the fact that a very small portion of the earth's magnetic field protrudes outside the earth's core, and it is precisely these loops that do extend outward that are thought to be related to the reasons why the earth's magnetic polarity shifts from time to time. In (18) *although* signals a contrast, but also the fact that the force dynamic strength of the event corresponding to the clause following *although* does not effect a change in the event referred to by the independent clause. In this case eventhough *the geodynamo produces a very intense magnetic field,* this magnetic field remains contained within the earth and *only about 1 percent of the field's magnetic force extends outside the core* (*although* and *despite* may also introduce obstacles without sufficient strength to prevent motion or action.)

From this perspective force dynamics expresses the interaction of two forces, one of which is trying to effect a change. *Because* introduces a stronger force that succeeds in imposing a change, whereas *although* and *despite* introduce a weaker potential cause (or obstacle) that does not succeed in bringing about a change.

Another distinction Talmy describes is the difference between steady state and shifting force dynamics depending on whether an interaction is conceptualized as lasting or just beginning or ending. Shifting force dynamic interactions are often lexicalized with circumstantial clauses. See (19) below:

(19) *When the upwelling force is strong enough to expel the loop from the core*, a pair of flux patches form on the core-mantel boundary.

In this example, the shift refers to a change in the relative strength of *the upwelling force.* This change is marked by the circumstantial clause: *when the upwelling force is strong enough to expel the loop from the core.* At this point the *upwelling force* overcomes the resistance of *the core* and *the loop* is expelled from the core resulting in the formation of *a pair of flux patches.* The result is contingent on the change in relative strength of *the upwelling force.* An understanding of how shifting force dynamic expressions are lexicalized in English can aid science students in determining whether a force interaction is steady state or shifting (lasting or changing).

An appreciation of which part of the causative chain is being focused on in a particular utterance aids students both in understanding the force dynamic interactions and the author's value system at particular points in the development of discourse.

In Figure 14 we can appreciate some examples of how Glatzmaier & Olson shift their focus on the causative schema. Events can be conceptualized as autonomous. In the first example causative factors are not denied, but rather only become apparent from the context of discourse. What is important at this point is the motion (not its cause). In the following examples, the author changes his focus from a resulting to a causing event and a schema of personified agent or instrument causation.

Figure 14. Semantic causative types

Conceptualized as	Example	Antagonist (opposing figure)	Agonist focal figure	Result
Autonomous event (not conceptualized as causative)	The fluid reaches the top of the core.			Motion (The fluid reaches the top)
Resulting event causation	*The core's high temperatures are the result of heat* that was trapped at the center of the earth during its formation.	Heat that was trapped… (Cause)	The core's high temperatures (Result)	Change: temperatures went up
Causing event causation	*Fluid rising through the molten outer core* pushes upward on roughly horizontal magnetic field lines within the core.	Fluid rising through the molten core (Cause)	Magnetic field lines	Motion (Fluid rising pushes magnetic field lines upward)
Personified Agent or Instrument causation	*The earth's rotation* simultaneously drives helical circulation of the molten[27] fluid.	The earth's rotation (Cause)	Circulation	The molten fluid circulates in helical manner

[27] *Molten*: liquified by heat.

Conclusions

On the one hand Mexican students at the ENP have signaled vocabulary as one of the most difficult problems they face when attempting to comprehend scientific texts in English. On the other, an important part of the message in each and every communication corresponds to one of a small number of underlying abstract conceptual schemas and the patterns that occur in these cognitive schemas are meaningful because they correlate with pre-conceptual structures in our daily experience. Thus it is pertinent to attempt tapping into these basic schemas in an effort to aid non-native students in comprehending unknown vocabulary from scientific texts in English. The underlying discourse schemas posited by Talmy & Jackendoff and validated in research on authentic corpora by Meagher (1999, 2004) seem most useful for Spanish speakers faced with the task of understanding scientific texts in English. In part this stems from the aspects of psychological reality that correlate with these schemas and their contribution to the construction of meaning. All these conceptual structures underlie both general conception and language.

Language is one of the most visible traces of cognitive processing available for analysis today (the others relating to neurological structures and/or processes). If an analysis of linguistic structure can be an aid in discovering the nature of thought, cognitive structures can also be of great use for science students with a need to comprehend academic texts in English.

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