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Editorial

Professional communication between experts becomes more and more demanding in terms of vocabulary, precision, and consistency irrespective of the language used for this communication. Although English is considered to be the global lingua franca in most professional and academic contexts, the precision and consistency holds true for professional communication in any other language. Contracts, technical reports, legal documents, multi-national company sites and a lot more tend to be required in more than one language, English will only in rare circumstances be sufficient, therefore the smoothest possible transition between languages – be it traditional translation or another form of rendering – must be ensured. That is why LSP must be constantly analyzed, developed, enhanced, disseminated, and even popularized, and specialists must be educated to handle these processes which are vital to ensuring knowledge transfer across all sorts of boundaries and growth in general.

Wrong beliefs that global English will be usable for all types of cross-cultural professional communication, that any non mother tongue speaker masters English at a sufficient level after leaving high school, and that machine translation can deal with what humans cannot, have various negative effects. One is the apparent low status of the translation industry and of knowledge work in general, and the lack of interest that students in various countries show in acquiring language and culture skills at a high level. Many seem to believe that if they study a subject, be it engineering, international marketing, legal affairs, or whatever, the skills to communicate in a foreign language, typically English, about the details of their domain, will develop gradually and all by itself. This attitude takes away focus from the real challenges of specialized communication and the need for data collection and dissemination, for multi-lingual and multi-cultural ontology building, as well as for research in these areas. The worst scenario is a generation of youngsters where very few realize the importance of making the serious effort it takes to become educated for efficient professional communication and all its aspects.

Henrik Selsøe Sørensen
Editor in chief

http://uk.cbs.dk/staff/henrik_selsoe_soerensen

Methods of concept analysis – tools for systematic concept analysis

Part 3 of 3

Anita Nuopponen
University of Vaasa
Communication Studies
Vaasa, Finland
anita.nuopponen@uwasa.fi

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Abstract

This article is the third one in a series of three articles which focus on development of concept analysis methods as an academic research method. In the first article, terminological analysis methods were contrasted with selected concept analysis methods developed in business studies and nursing science. The second article discussed a further development of *systematic concept analysis*, and outlined steps that can be taken when analyzing concepts for various purposes. This third article describes tools that could be utilized in various phases of concept analysis as well as in other phases of research. With the help of these tools the researcher can bring order in concepts, concept systems and terminology as well as in content and knowledge structures of the study all the way from the design of the study to the presentation of the results. The tools introduced here consist of a mind-map-like graphical presentation called "satellite model", and eight models that can be utilized to structure the satellite model presentation: basic, structural, origination, developmental, activity, transmission, causation, and dependency models.

1 Introduction

Analysing and clarifying concepts and their relation to each other is an integral part of any scholarly research process. In some cases, the analysis is very restricted and performed in the background at certain phases, while in other cases it may cover larger areas or even the whole research process. In the previous paper (Nuopponen 2010b), a systematic concept analysis method was presented as a method for this work. Figure 1 shows the steps of the analysis method presented. Systematic concept analysis may either be the only research method utilized or function as an auxiliary method in all phases of the research process.

This third article concentrates on some of the tools which can facilitate concept analysis at the various stages of a research process, especially at steps 2-5 in Figure 1. The tools were originally devised with terminology work in mind. In addition to concept analysis, they can be applied for other purposes. During a research process it is not only established concepts, but

also various kind of facts, information and knowledge that need to be analysed, compared, systematized and organized (see e.g. Pilke 2010; Nuopponen 2005b).

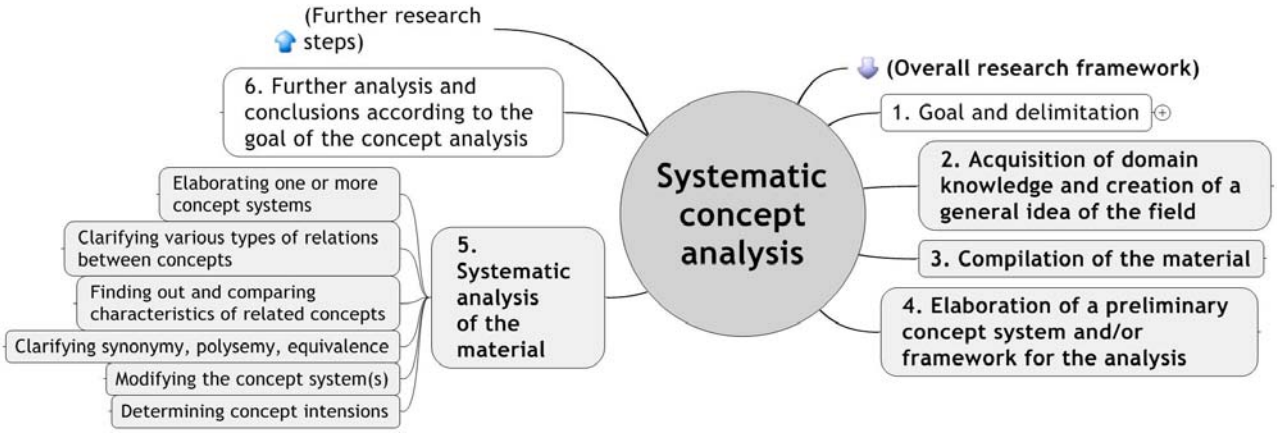

Figure 1. Systematic concept analysis (Nuopponen 2010b)

The tools to be presented in the following are a **satellite model** - a graphical mind map-like knowledge and concept presentation - and **concept relation models**: a basic model and structural, origination, development, activity, transmission, causation, and dependency models. This set of tools is based on the idea of building one or more concept maps or concept systems of the field starting from the preliminary compilation of knowledge (~ phases 1-3 in Figure 1) and structuring of the field (~ phases 3-4). For each separate map, a concept is selected as the point of departure in order to achieve a preliminary overall picture of concepts and concept systems of the target field. The branches are then scrutinized separately with the help of the models - and with separate satellite models if needed (phase 5). While doing this, the tasks listed in phase 5 are carried out. As a synthesis, a new version of the whole concept system (or ontology) is compiled (phase 6). The results can be utilised in further stages of a research process.

2 Satellite model - a graphical presentation tool for concept analysis

Satellite model is a mind map-like graphical presentation, which was created with the systematic terminological concept analysis in mind (Nuopponen 1994; 1997). It is more flexible than the traditional tree diagrams presented in terminological literature (e.g. ISO 1087); new nodes can be easily added when drawing by hand or when using a mind mapping software. Actually, it is as hierarchical as the conventional tree diagram: the branches are spread around the uppermost concept (here: core concept) instead of being placed under it, allowing thus more space for the branches. The use of this type of graphical representation solves also the need to establish and to learn a different type of representation for each type of concept relation (Nuopponen 1997). This type of graphical representation is dynamic and can be expanded, modified and specified during all the analysis process. The satellite model approach takes one concept in focus at time as is done in the figures 1-8, but each of the nodes may get its own satellite nodes around it. It can even serve as a core concept in its own satellite model. A core concept may be a concept on a higher abstraction level or a concept that otherwise is central to the field in question and is able to link together the selected concepts. Depending on the concept analysis needs at hand, it may refer e.g. to a discipline or another area of expertise, or a part of these (e.g. *linguistics, lexicology, legal system,* etc.);

activity, action, process, procedure (e.g. *word formation, term extraction, legislation*); or material or immaterial object, state (e.g. *language, morpheme, legislature* etc.).

In order to keep the presentation illustrative and clear, it is recommended to utilize the satellite nodes as meta-concepts such as *parts*, *types*, *functions*, *instruments*, or include more precise expressions for the concept relations (e.g. "generic relation", "partitive relation", or "temporal relation") in the nodes. These auxiliary nodes can be left out, e.g. in cases when the type of the relation is either obvious or difficult to define. The following sections deal with different types of meta-concepts and concept relations, which will offer alternative possibilities for starting an analysis. One of the models can be taken as the initial model; e.g. if the core concept is an activity concept, the most important meta-concepts will be *actor, object, tool*, etc. The object concept may in its turn be analysed as to its origination or dependencies.

3 Concept relation models

During the first phases, the satellite model could be utilized in a mind map-like manner without putting much emphasis on the types of relations between concepts. However, in order to get a more accurate picture of the concepts of the field, more precise models can be applied. They can be utilized also earlier in order to get a quick start on concept analysis. The models presented here originate from my previous studies where I have compiled detailed classifications for the types of concept relations and concept systems for terminological concept analysis and terminology work (e.g. Nuopponen 1994; 2005a). To refine the original classification presented in Nuopponen 1994 I have utilized e.g. the hierarchy of semantic relations which has been used by Madsen et al.1 for instance for developing an ontology-based querying system. (See e.g. Madsen et al. 2001; 2002; Nuopponen 2005a). The classifications offer a top-down approach to the various types of relations there might be between concepts in any field. In order to apply them in practice, however, I have started to formulate models by grouping certain relation types together (e.g. Nuopponen 2006: activity; 2007: process; 2008: causality). Some of the relation types are to be found across different models thus resulting in mixed concept systems.

The concept relations types are (over)generalized and kept in an abstract level in order to make them applicable for all possible cases from different domains. They are based on basic structures and categorizations of the world. The terms that have been selected to designate the different relation and concept types are chosen either to be general enough (e.g. *locative relation; place*) or because they are metaphorical loans from a certain domain and express something essential of the relation or concept type in question (e.g. *ingredient relation; patient*). The purpose has been to leave space for interpretation according to the needs of the actual domain and the approach selected by the researcher.

In the figures 1 have marked the meta-concepts with capitals (e.g. COORDINATE CONCEPT), but mostly left away 'concept' in the end (e.g. PARTS, CORRELATE). The questions to be asked are focused on finding out the phenomena, the objects of reference and thus also the concept. As to the questions, the core concept is in the focus and functions as the starting point. For instance, if *research* is taken as the core concept, the question *Where is the activity performed?* can be answered with *university*, *research institute*, etc. establishing thus locational activity relations between these concepts and the core concept. In many cases the

[1]For the details of their classifications, see e.g. Madsen et al. 2001; 2002.

relations can be approached from both directions: the core concept may refer to a part in a whole or to a whole that has its own parts. In some cases both of these possibilities are marked in the models, but not in all possible cases.

3.1 Basics: types and properties

The first model combines the basic information that is needed for writing definitions for concepts - both related concepts and characteristics (Figure 2). When a phenomenon is being scrutinized, there almost always is information available about a larger group of phenomena that it could be classified in. This means that irrespective of whether concepts refer to concrete or abstract phenomena, it is possible to establish their place in a generic concept system[2]; i.e. to identify the concept's superordinate, subordinate, and coordinate concept(s) (e.g. *concept analysis: research method, systematic concept analysis, content analysis*).

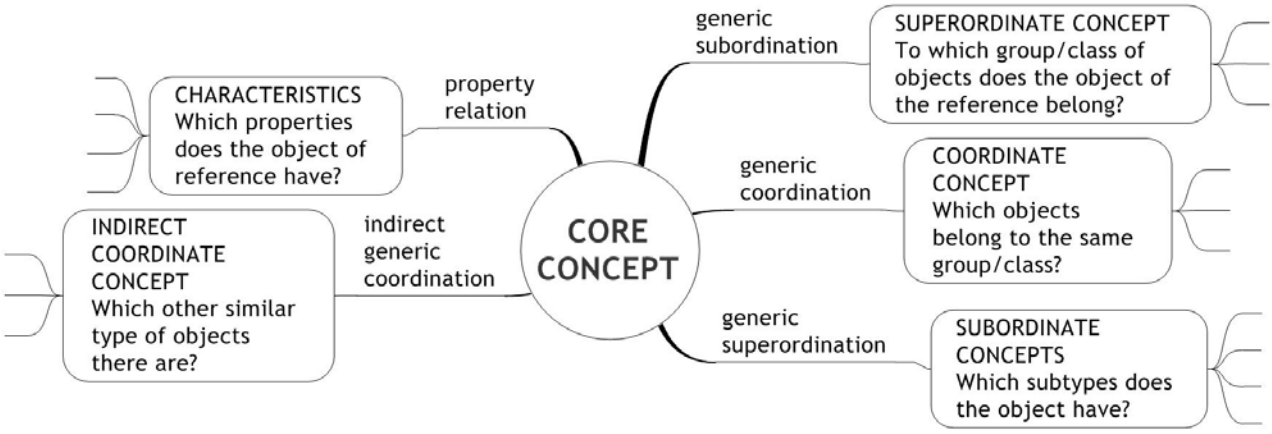

Figure 2. Basic model[3]

Even though this model might seem to be a clear cut one, it is not always easy to analyse these concepts. It may sometimes be difficult to locate a generic superordinate concept; and in other cases, alternative superordinate concepts may be found, e.g. *chadô,* the Japanese tea ceremony may be treated as a type of ceremony, ritual, art, cult, tea drinking, philosophy, religion, etc. (Nuopponen 2007) A difficulty may appear when the core concept or its superordinate concept is under discussion and not yet established in the field; or when there are several overlapping concepts which do not together form any of the models discussed here. Sometimes, they may be subordinate to the same concept but not necessarily, in which case each of them may need a separate presentation to guarantee "fair treatment". Instead of one core concept, the analysis would start then from several parallel core concepts with a purpose to find a basis for comparison.

If the concepts are not directly subordinated to the same concept on a higher level of abstraction, they may be located in the same generic concept system e.g. as indirect coordinate concepts, or in competing alternative concept systems. It is important to describe the concepts with reference to their own concept system first before comparing them to each other.

[2] Syn. logical concept system (e.g. Nuopponen 1994)
[3] The figures are to be read clockwise and started from 1 o'clock. The term *object* is used as a synonym to *object of reference* in the figures. Both refer here to the object of reference of the core concept.

In order to be able to define concepts, it is necessary to identify the characteristics that distinguish from each other and the neighboring concepts on the same abstraction level. Therefore, I have included in this basic model also characteristics, i.e. answers to the question *Which properties does the object of reference have?* The answers may be expressed with lengthier extracts from the sources or more concise expressions. Some of them express also various types of relations to other concepts. Satellite nodes for characteristics can be added to each of the concepts and their subordinate concepts - not only to the core concept as in the model in Figure 2. In this way it, is possible to get a preliminary overview of the contents of the related concepts and compare them. Additionally matrices or tables may be used for more accurate comparisons.

3.2 Structure: composition and location

The second model comprises mostly concept relations that refer to some kind of spatial contact in between the referents of the related concepts (Figure 3). Here, the key information concerns partitioning of the referent in its components, elements, or properties etc. Questions like *Which wider whole does the referent belong to?* lead to information on the partitive superordinate concept of the core concept. Other concepts will be found with questions: *Which other parts belong to the same whole?* or *Which parts or components does the referent consist of?* In addition to the actual components, it is possible that some extra parts can be attached to the object of reference, e.g. *e-mail – attachment*. When analysing concepts that refer to abstract phenomena, it may not be possible to make any difference between partitive and material component relations (e.g. friendship, trust).

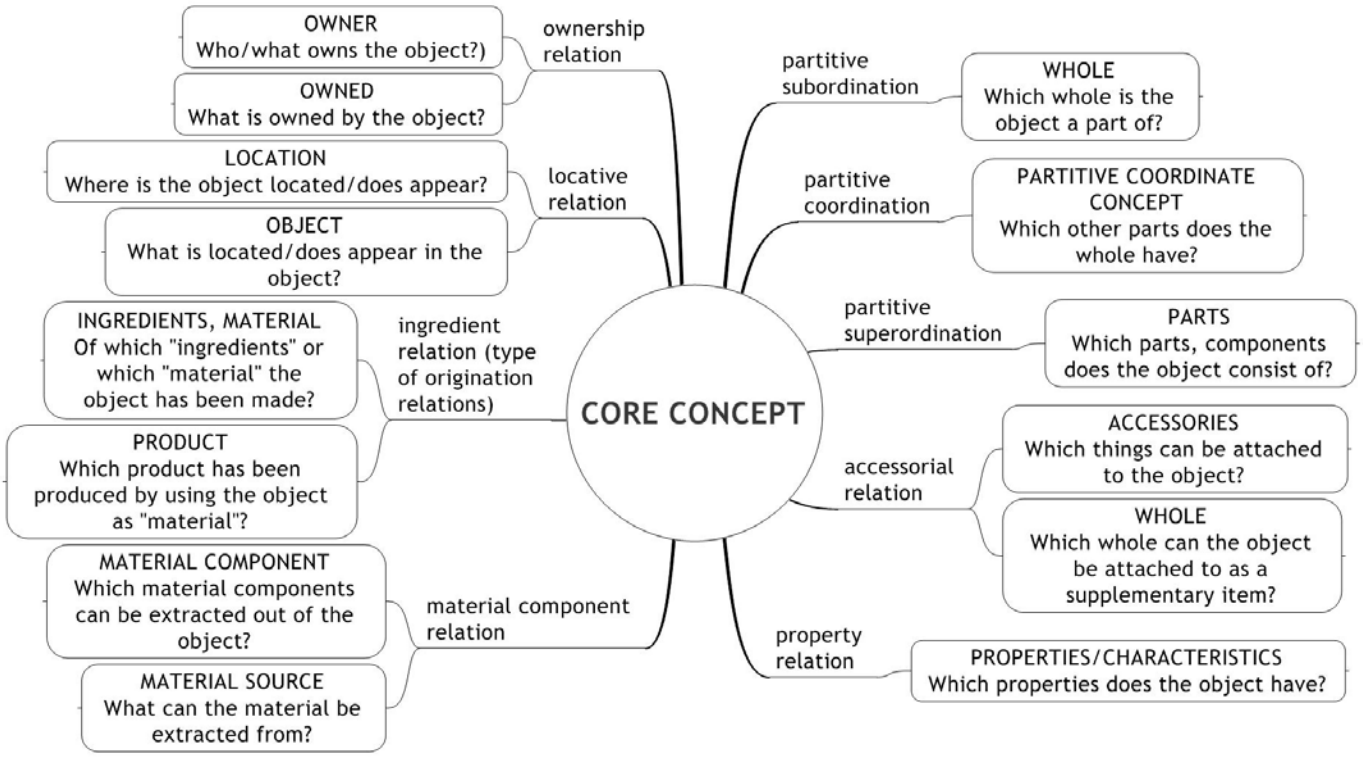

Figure 3. Structural model

Accessorial (or enhancement) relation is not always distinguishable from partitive relations, but it may be useful to treat it separately. It refers to the relation between two entities, one of which can be attached to the other one without being an actual part of it (e.g. *car - trailer; computer - memory stick*). The p**roperty** relation that was integrated also in the previous

model, concerns here relations like *silk - strength*; *wind power - sustainability*. **Material component** refers to the material that the object contains or which can be extracted from it (*coffee - caffeine*), and is often different from the material that is used to make the object (**ingredient** relation). An example of **location** could be *coffee plant - coffee plantation*. **Ownership** relation has to do with the owner and the object, e.g. *coffee grower - coffee plantation*.

3.3 Origination, development and processes

Models with origination, developmental and process relations help e.g. to sort out various types of background information on the research object (stages, place of origin, initiators etc.). For instance, textbooks, encyclopedia and dissertations start the description of a phenomenon by giving details of its origin and development. **Origination** relations are based on relations between the referent of the core concept and other phenomena that have to do with the origin e.g. of a product: *producer, place of manufacture, purpose for manufacturing, manufacturing method, used material, instrument, manufacturing time,* etc. (Figure 4). It could be historical and hypothetical connections (e.g. *universe - Big Bang*) or something that is happening all the time (e.g. *vowel - tongue*). All of these may have several alternatives, e.g. place of origination in case of *vowel - front/near front/central/near back/back of the mouth*.

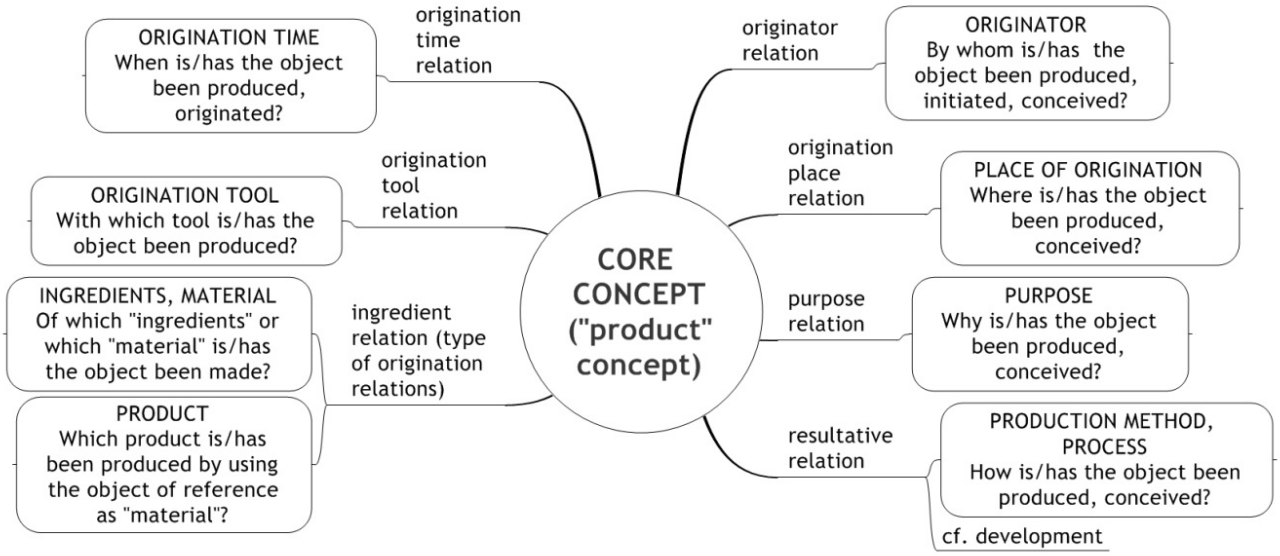

Figure 4. Origination model

It may be easier to find this information when analysing a concrete phenomenon compared to an immaterial phenomenon e.g. an activity. **Ingredients** that e.g. cappuccino is made of are *espresso* and *foamed milk* while e.g. Japanese tea ceremony (when regarded e.g. as an art form) is "made of" ingredients from various religions, architecture, other art forms such as ikebana, calligraphy etc. which have steered the development of the tea ceremony.

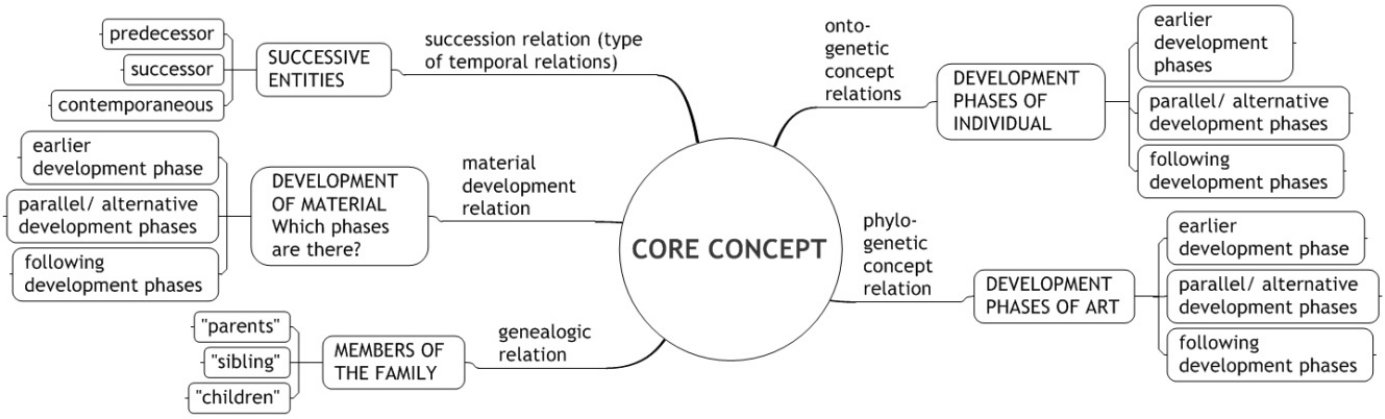

Figure 5. Developmental and temporal model

Developmental relations (see Figure 5) supplement the previous model with origination relations. In this model the purpose is to analyse various developmental phases of an **individual** (e.g. *child - adult*), a **species** (e.g. *grey wolf - domestic dog*), a **family** (*mother dog - puppy*), or **material** (e.g. *dough - biscuit; water - ice*). In addition to these developmental relations, also various types of **temporal** relations may be analysed in this context, i.e. which phenomena or events precede, succeed, or co-occur or co-exist without being "genetically" related to each other.

3.4 Activity

Activity relations (see Figure 6) help bring together many separate concept systems and fragments of systems in a larger concept system or an ontology of the field. In the activity model, an action, an activity or a phase of a process is taken as the starting point for the analysis.

Activity relations are based on a connection between an *activity* concept and phenomena involved in the activity and the questions to be asked concern e.g. *agent, object/patient, tool, location, time, purpose, result, etc.*). For some activities it is possible to distinguish a route (e.g. *cycling - cycle lane*), or a source and a target (location), e.g. for translation, *source language* and *target language*.[4] The model has been supplemented with **phase** relations that are a type of temporal concept relations and can function as a link to a more extended series of activities.

[4] Activity relations and concept systems have been treated more thoroughly in Nuopponen 2006.

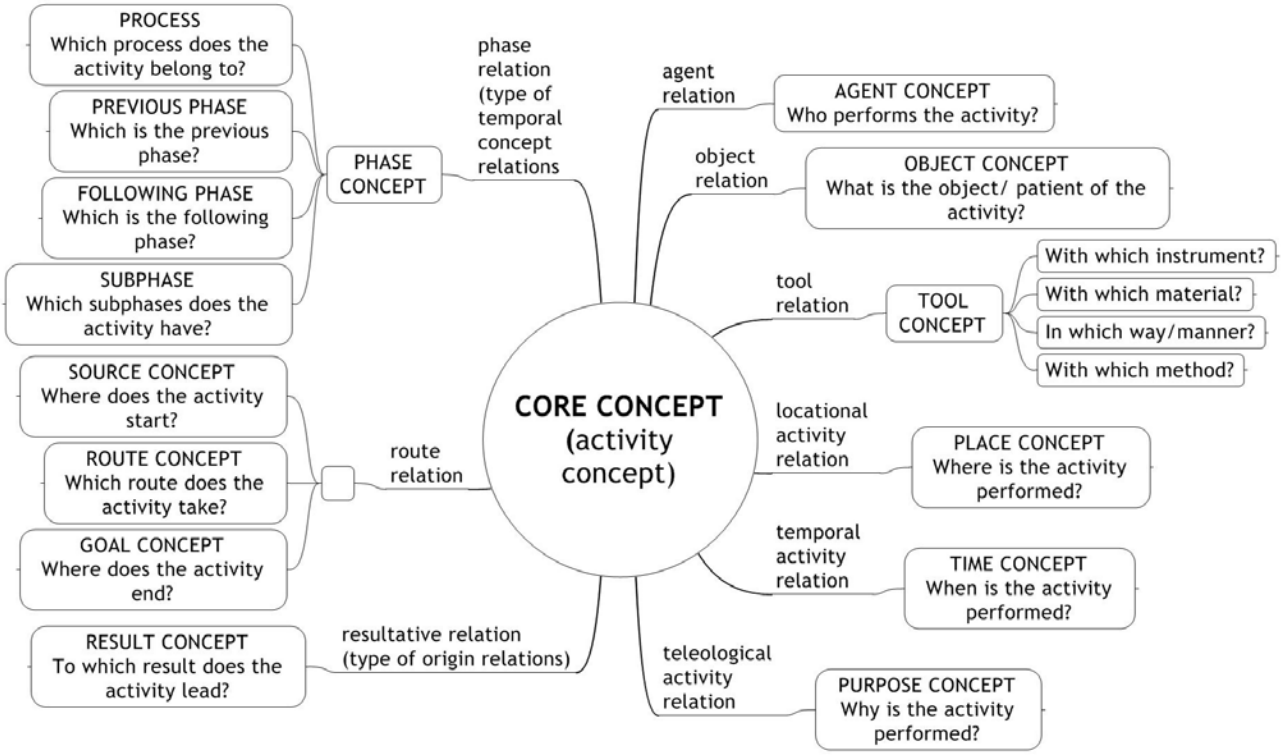

Figure 6. Activity model

3.5 Transmission

One type of activities is made of different types of transferring or **transmission** processes (see Figure 7). This is dealt with as a separate model because these processes bring more complexity. If a concept referring to a transmission process is taken as the core concept, the activity model can be applied to a certain degree. In transmission concept systems, however, any other concept may be taken as the core concept, e.g. the concept referring to the object to be transmitted or transferred as in Figure 8.

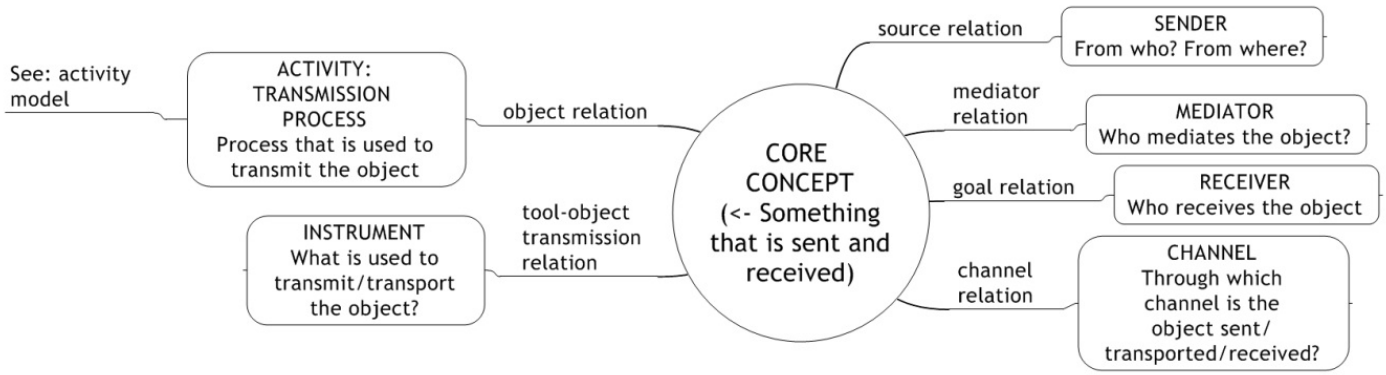

Figure 7. Transmission model

Transmission relations are based on the basic transfer: A gives/sends/transmits something to B (e.g. *transmitter - receiver, coder - decoder*). Other relations involved are source relation (*sender/place - entity*) and target relation (*entity - receiver/ place*). In the activity model, these relations were used not only to refer to sender and receiver, but also to the place of departure and destination. However, it may be necessary to distinguish between these two sets of concept relation in some cases (Nuopponen 2008). In addition, Figure 8 includes also a relation between the core concept and the concept the referent of which is a *mediator*, i.e. someone that is neither the original sender nor the final receiver.

3.6 Cause and effect

Causal relation is often seen as a relation between the concepts of cause and effect (causal sequence), but this is only the basis for a complex concept system that is often involved. In causal concept systems, it is possible to distinguish between concepts referring to various types of **causes** and various types of **effects**. The causes may be an **agent** causing something, an **event** that may start a whole chain of events, or **state**, condition or circumstance that can have a decisive role in the whole process of causation. There is always "a patient", i.e. something in which the effects show and appear as **symptoms**.[5]

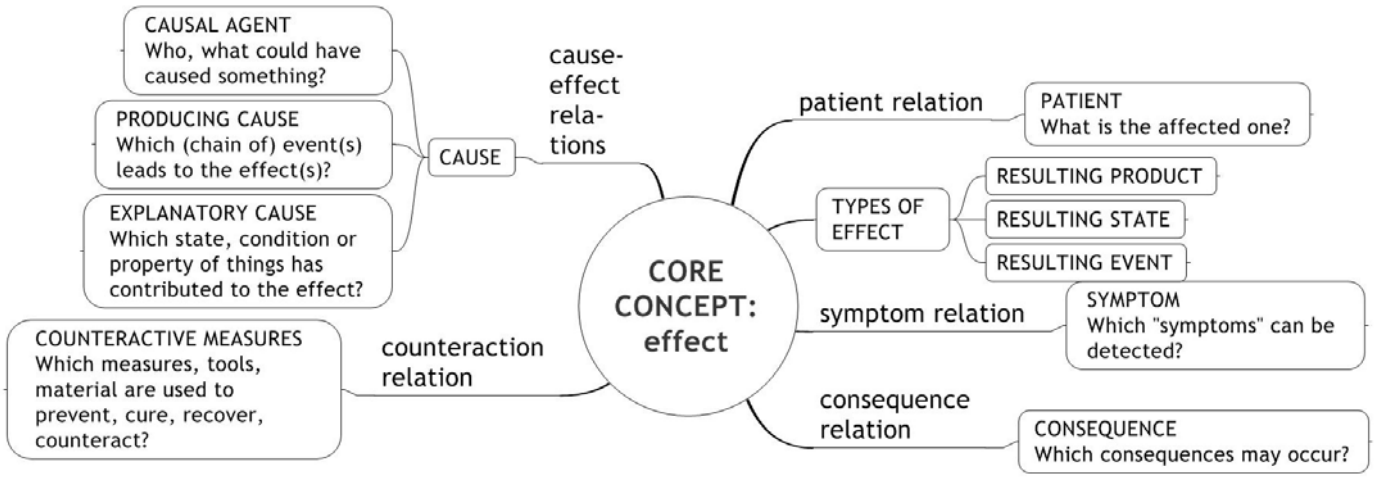

Figure 8. Causation model

The effects may be product, state or an event and can lead to consequences. On the other hand, there are various types of countermeasures to prevent the causation chain or the effects to appear, or cures for the symptoms, effects and consequences. In a study where there is some kind of cause-effect relation to be detected, this model may function as a starting point for organizing the concepts (e.g. various types of *communication failures* and their causes and countermeasures as well as consequences). The research question may also be an opposite one: to find out why something was successful, what were the causes, what kind of positive effects occurred, and which consequences did they have.

3.7 Dependence and comparison

The model in figure 9 combines relations that are not forming any coherent concept system, nor functions as a basis for a satellite model as such. It rather accounts for various types of

[5] For examples see Nuopponen 2008.

concept relations that combine concepts referring to objects that are being compared or are dependent on each other. The relations presented here may be integrated in other models according to the needs. For a researcher they may offer further ideas e.g. for how to analyse the collected material. In my concept relation classifications these are classified mainly as contact or interactional relations. Role relation is added here to cover not only the role change relation (between consequent roles of the object of reference) from the earlier classifications but also the relations between the core concept and various role concepts referring to object's roles related to time. [6]

Ownership relation appeared already in the contact model but can belong also here. It is based on the connection between the owner and something that is owned. These relations are often near partitive or accessorial (or enhancement) relations, but may be applied in some cases when the ownership is particularly focused, e.g. *copyright - copyright owner*. Sometimes "owner" must be taken as a metaphor.

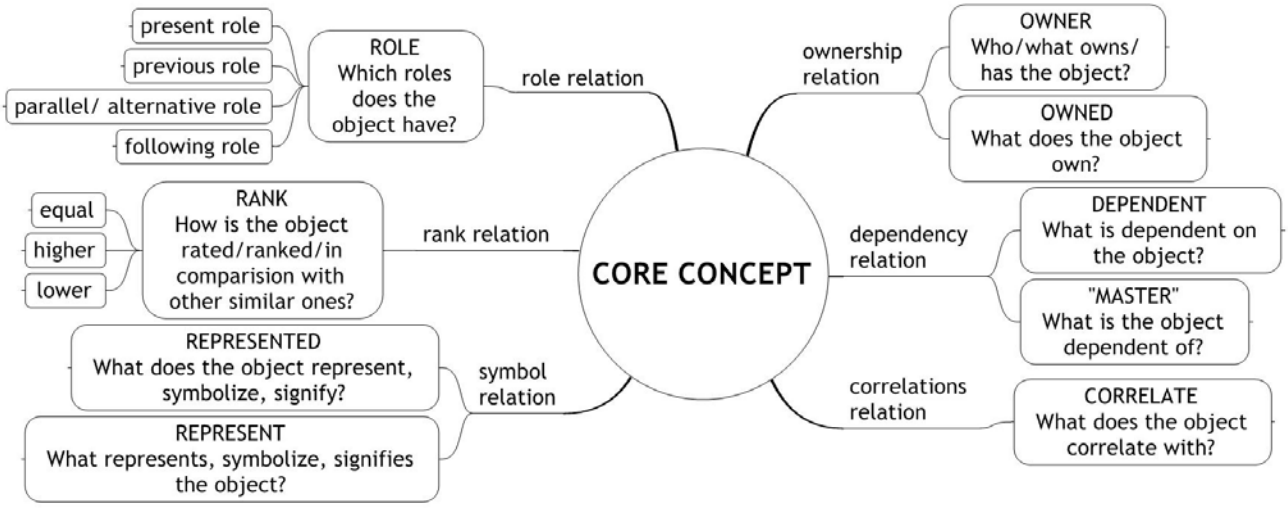

Figure 9. Dependency model

An example of **dependency** relation is *lender - borrower*. These types of relations are based on various types of economic, legal and other similar relations which may exist between different parties. **Correlation** relation may be otherwise rare type of concept relation, but is often needed in a research process. It refers to a reciprocal relationship between entities (variables), e.g. *oil price - stock market*. **Representational** relation has to do with the relation between an entity and its representative (e.g. *meaning − word, people − parliament*). **Rank** relation is based on comparing, rating or ranking phenomena as to some of their property, e.g. different levels in military: *sergeant - corporal - private*, or in taxonomy: *species - genus - family - class*. **Role** relation depends on the role of the phenomena, e.g. *professor - supervisor; journalist - gatekeeper*.

[6] See more in Nuopponen 1994; 2005.

4 Conclusion

The idea behind the systematic concept analysis is that "no concept is an island" - to modify John Donne's[7] statement. Every concept analysis involves other concepts and the relations need to be scrutinized. When doing research, however, much of the concept analysis is done by thinking, and the results are presented by discussing for instance different views, definitions, or classifications. In this paper, however, a set of "tools" was presented to make concepts and relations between them visible in a graphical diagram. The tools consist of several models that are built on previous research and bring together various types of concepts and concept relations across more formal typologies to form mixed concept systems (see e.g. Nuopponen 1994, 2005a).

The models are meant to give ideas for structuring and comparing concepts during different phases of a research project regardless of whether concept analysis is utilized as the main method for analyzing the research material or only as an auxiliary method e.g. for clarifying concepts of the theoretical framework or the background information of the research object (cf. Nuopponen 2010a, b). Components from all of the models can be integrated in one single concept map model as a satellite system, or they may be represented separately. During the systematic analysis, the emphasis may shift from the core concept to another concept which combines more concepts around it than the original concept. Separate alternative satellite models are needed when comparing concepts according to various theories, methods, previous research results etc. to create a basis for comparison in the same way as when concepts and terms of two or more languages are analysed. With the help of the models the researcher can show the differences and suggest his/her own structuring of the concepts and terms and motivate the choices done (see Nuopponen 2010a, b).

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Inter-subjectivity, cognition, nature and multimedia representations: modal categories in professional discourse

Maria Tarantino
Dipartimento Interateneo di Fisica
Università e Politecnico di Bari
Bari, Italia
tarantino@fisica.uniba.it

Keywords: *multimedia discourse, objective, alethic, modal categories*

"This study is respectfully dedicated to the memory of Jacques Qvistgaard who promoted the study of languages in professional fields."

Abstract

Leading studies of the English modal auxiliaries generally classify the epistemic category as bearer of personal beliefs. Proposals that, when conveying quantitative properties and physical characteristics, this modal class may perform *objective* and *alethic* functions remain peripheral to the discussions. As a result, connotations which relate to physical evidence, conform to the epistemology, pragmatics and ethics of disciplinary domains and contribute to the woof and warp of professional or 'multimedia genres' abide unattended.

The study explores whether *objective* and *alethic* functions of epistemic modals may deserve attention in analyses of professional discourse. An outline of influential descriptions of modal categories reveals a common line in their conceptualisation of epistemic particles as bearers of subjective beliefs. The stance invites a reflection on the epistemico-pragmatic evolution which brought 'beliefs', in science, to depend on accessible evidence, mathematical models, inter-subjective knowledge and multimedia representations. Scholarly arguments follow which emphasise the epistemico-pragmatic grounds of 'probability' modals, in 'possible worlds' genres, and propose specifications of *objective* and *alethic* categories. The aims and 'possible worlds' relevant to scientific investigation and argumentation are briefly touched on. Then, evidence of two epistemico-pragmatic functions is offered through the characterisation of modals in texts of different realms of science.

The discussion indicates that in scientific reports epistemic modals bear connotations which must be worked out in light of verified knowledge. The latter is space/time-related, inter-subjective and bound to conceptual models and inter-disciplinary frames of reference. These specifications constitute *alethic* and *objective* meaning sources relevant to the practices of thought communities. Therefore, descriptive models of professional discourse might benefit if they were inclusive of the two pragmatic functions.

1 Introduction

The English modal auxiliaries have been a main topic of interest in theoretical and applied linguistic studies. Most of the discussions have dealt in depth with the grammar elements of the system and provided explanations of the possible meanings of each constituent. However, the complexity of the subject has led to no satisfactory interpretative model (Hoye 2005; Lyons 1994; Palmer 1979, 2003; Papafragou 2006). The debate is still open both on whether modal forms should be considered polysemous or monosemous, and on whether the *epistemic* class is an offshoot of the *root* modals or vice versa (Coates 1983; Kratzer 1977; Traugott 1989). Researchers from both camps have provided interesting details on the syntactic properties of each modal particle, and determined their frequency and distribution in sentences either created introspectively or attested in spoken and written corpora (Biber et al. 2007, Palmer 1979; Quirk et al. 1985).

In the literature, there appears to be general agreement on the possible meanings carried by the *deontic* or *root* category (Brown & Levinson 2009; Leech 1986). However, the connotations conveyed by the *epistemic* class seem not to share the same consensus. In fact, the functions of epistemic modals are characterized according to two schools of thought. One, 'subjective/relativistic' oriented, frames epistemic elements mainly as bearers of personal beliefs and opinions; the other, 'naive realism' based, argues for the widening of the semantic domain with *alethic* and *objective* subclasses. The latter would encompass connotations interweaving pragmatic patterns, physical properties and statistical data relevant to research communities (Lyons 1994).

For different reasons, among which easier access to their studies, the model elaborated by the 'relativists' prevails in language research and teaching environments. Whereas, the addition of the sub-classes proposed by the 'realists' remains unexplored in both general and specialist language studies. Influential essays by the relativists mention proposals that discourse analyses should open to *objective* and *alethic* meaning strands, but the specific functions have been deemed either of little relevance to ordinary speech or non-indicative of 'real-world causes' (Palmer 1979; Sweetser 1998). Consequently, the significance of *epistemic* modals remains fastened to degrees of possibility or necessity related to subjective opinions and beliefs (Halliday 2004).

Undoubtedly, the descriptive models elaborated by the relativists provide interesting observations and insights into modal functions. However, the emphasis on subjective evaluation seems to obscure distinctions between beliefs based on sheer looking, testimony and authority and 'belief ascriptions' involving objective evidence, non-verbal and pragmatic patterns which foster multimedia discourse. More effective studies of domain-specific language may require taking into account the influence that systematic observation of physical phenomena, presuppositions, technical skills, purposes and representation patterns shared by the interactants may have on what linguistic forms can mean and suggest (Stalnaker 1999). In this perspective, the qualification of modal meaning should be also in light of "… shared assumptions, values, beliefs, and conventions of behaviour that define the culture of particular discourse communities" (Widdowson 2003:68).

The present study explores whether strands of *objective* and *alethic* meaning proposed by the 'realists' may be relevant to the description and interpretation of professional and/or multimedia genres (Lemke 1998). This constellation of 'discursive practices' binds

communities of researchers in an interdisciplinary quest to advance understanding, visual representations and explanations of "… innumerable arguments from nature" (Galilei [1610] 1989:57)[1]. The participants in the research and argumentation activities are aware of the complexity and variability of natural phenomena. Their academic training and every day experience with thought and laboratory experiments incite them to investigate and discuss physical entities and processes as being in constant flux, and thus, amenable only to probabilistic propositions and provisional claims (Toulmin 1980).

The study first outlines influential studies on modal categories and traces a common line in their definition of the epistemic mode in terms of subjective 'beliefs'. The topic invites a reflection on the meaning of the concept of 'belief' in science as well as on the historical event which led to the expansion of the word reference-frame from subjective or authority-based speculations, to verified, quantitative properties. The origin of the epistemico-pragmatic transition is located in the founding of the scientific method by Galileo Galilei (1564-1642). It is recalled that, in the effort to free science from authoritative and dogmatic impositions, Galileo characterises beliefs in terms of their origins, grounds and reference frames and argues for a net separation between scientific and other discourse genres (Galilei [1623] - 1957). Reference is made to the epistemology and argumentation style proposed by the scientist which render research activities, investigation tools, reasoning processes, and findings ostensible, repeatable, probabilistic, and open-ended.

The considerations on the specific nature of scientific beliefs and argumentation lead to discuss proposals by scholars, in different academic fields, who sustain a pragmatic approach to discourse analysis and propose that modal functions should be widened with the inclusion of *objective* and *alethic* sub-classes. The argument binding these proposals is located in the specification that the meaning of modal particles should be established in light of knowledge patterns, context of interaction, purposes and codes shared by participants in the speech event. These elements are deemed responsible for 'possible worlds' knowledge frames and belief attributions (Stalnaker 1999). The 'possible worlds' or 'realms' of knowledge investigated and represented by science are briefly delineated. Then, the analysis of modal particles in scientific texts offers evidence of *objective* and *alethic* functions in multimedia genres. The discussion invites the conclusion that more adequate descriptions of scientific discourse may require widening the conceptualisation of modal functions to include the two sub-categories. Besides allowing more comprehensive definitions of the relative epistemico-semantic elements, the enrichment could contribute to more effective research and interpretation models of professional communication.

2 Framing a complex grammar-semantic system

The modal auxiliaries belong to the macro-class of grammar elements comprising verbs, adverbs, nouns and adjectives considered as a cross-linguistic facility (Palmer 2003; Hoye 2005). In social interactions, the variegated group of linguistic forms can indicate/mitigate request, advice, obligation, permission, apologies, conventional rules (Brown & Levinson 2009; Leech 1986). In interpersonal exchanges of ideas, they can attenuate assertions, convey degrees of individual certitude and/or doubt about possibility of events (Austin 1970). In professional discourse, along with the aforementioned shades of meaning, they can subsume and grade confidence in investigation techniques, instrumental precision, standards of statistical data, as well as highlight deductive inference, reliability of claims and contingency

[1] All the quotations from Galileo Galilei's works are from the texts reported in the references.

of conclusions (Lyons 1994).

Influential linguistic studies indicate that modality items can function both as grammar and as meaning elements, thus, their description belongs to the area of grammar-semantic research (Huddleston 1984; Palmer 1979, 2003). They provide intra- and inter-linguistic descriptions of the relative particles and deal in depth with " … the distinctive grammatical properties of the central and peripheral modal auxiliaries …" (Huddleston 1984:164). In view of frequency of occurrence in spoken and written texts, they define *can*, *could*, *may*, *might*, *shall*, *should*, *will*, *would*, *must, ought to* as central modal auxiliaries (Leech 1975).

A finely detailed theoretical, descriptive and terminological framework for modal auxiliaries (henceforth modals) is offered in *A Comprehensive Grammar of the English Language* (CGEL), by Quirk et al. (1985). The notable study, which has been defined as " … probably the most detailed grammar of present day English yet written …" (Biber et al 2007:7) classifies modal functions into two meaning types:

a) Those expressing 'permission', 'obligation', and 'volition,' which involve some kind of intrinsic human control over events, and

b) Those such as 'possibility', 'necessity', and 'prediction', which do not involve human control of events, but do typically involve human judgement of what is or is not likely to happen (Quirk et al. 1985:219, original indentations and capitals).

The components of group 'a' are then categorised as bearers of *deontic* relations, those of group 'b' as conveyers of *epistemic* inference. CGEL explains that *deontic* modals carry *intrinsic* meaning since they relates to actions and events controlled by human or other agents. The *epistemic* class conveys e*xtrinsic* meaning because it refers to the logical status of events or states and is mainly related to grading of possibility, necessity or prediction (Quirk et al. 1985:219). CGEL observes that since each modal element belongs to both the *deontic* and *epistemic* classes, "… each one of them has both intrinsic and extrinsic use, …" (Quirk et al. 1985:219), i.e., each particle can bear either one or the other category of meaning. The discussion then details other peculiar semantic characteristics of modals. These include: trans-categorisation of functions, scalar value of elements, multiple time reference (might/should, may/can - may relate to past, present and future events), interchangeability of meaning (may/can/will, should/ought to - may indicate possibility/probability, expectation, etc.). In view of the complexity and polysemy of the modal system elements, CGEL observes that "… the use of modal verbs is one of the more problematic areas of English grammar" (Quirk et al. 1985:220).

The Authors of CGEL concur with other grammar-semantic experts that the difficulty met in accounting for the choice and significance of modals may arise from the fact "… that their meaning has both a logical and a practical (or pragmatic) element" (Leech 1975:66 - original parenthesis). But the question about whether, besides subjective opinions, the epistemic class can be related to pragmatic, dialectic and ontological characteristics of discourse domains appears to remain under-explored. In fact, almost all the studies on the functions of this category seem to echo the conclusion adduced by CGEL:

> At its most general, modality may be defined as the manner in which the meaning of a clause is qualified so as to reflect the speaker's judgement of the likelihood of the proposition it expresses being true (Quirk et al. 1985:219).

The comprehensive and insightful analysis of modal categories provided in CGEL is interrelated with many other significant contributions on the subject (Hoye 2005). Some of these enrich grammar-semantic descriptions with theories about both the possible diachronic evolution and the cognitive implications of each particle. Among these, Palmer's *Modality and English Modals* (1979) is undoubtedly the most enlightening and thorough description of the grammar-logic of the English modal system. In the classic text, the eminent scholar describes each modal particle in relation to mood, voice, time, and other logico-semantic features. Palmer observes that "… there are not just two kinds of modality" (Palmer 1979:35). Thus, he widens the modal classes with two subclasses termed 'dynamic possibility' and 'dynamic necessity' which express 'subject oriented and neutral possibility', respectively (Palmer 1979:71). He explains in depth features of *deontic* and *epistemic* modality and comments that nuances of the former class tend to shade into the ones of the latter, thus a net distinction between the possible meanings of the two categories is hard to draw.

Palmer then focuses on the connotations of the *epistemic* category, and specifies that this class conveys meanings such as "… I judge it to be possible…., I make it to be possible" (Palmer 1979:38). Then, he characterises further the relative elements as bears of "… the modality of propositions rather than of actions, states, events, etc." (Palmer 1979:41). The meaning space of the epistemic functions is set within "… degrees of possibility and necessity …. marked by MAY and MUST", respectively" (Palmer 1979:41 - original capital letters). After highlighting the tentative implications of *might*, *would*, *should,* Palmer specifies that *will* subsumes expectation (Palmer 1979:41, original italics). He illustrates the logical implications of 'will' and 'must' through the expressions:

a) John will be in his office.
b) John must be in his office.

In utterance 'a' "…*Will*… merely makes a confident statement, …" while in 'b' " … *must* suggests a confident conclusion from the evidence available" (Palmer 1979:47). The model of analysis proposed by Palmer is insightful and progressive. In his later contributions, he introduces the concept of 'evidential modality' and explains: "There are two main kinds of evidence – report and sensory" (Palmer 2003:7). The latter refers to sensory evidence, the former "… to what has been or is said by individuals or by community" (Palmer 2003:8). Thereafter, Palmer specifies that: "… Epistemic MUST and WILL have some characteristics of Evidential modality, for they signal conclusions that are based on evidence …" (Palmer 2003:8, original capitals). The two functions are defined by indicating the grounds for the assumptions:

a. *They must be in the office*. (The lights are on)
b. *They'll be in the office*. (They always are at this time) (Palmer 2003:8 - original parenthesis).

In the utterances, "… MUST indicates a conclusion based on available evidence …. while WILL suggests a conclusion from what is generally the case …" (Palmer 2003:8 - original capitals). The two types of conclusion are further defined in terms of underlying reasoning

process as 'deductive' and 'assumptive', respectively, which relates them to both reports and sensory experience. Afterwards, Palmer re-classes the four modal types: "Epistemic and Evidential modality might, then, be characterised as "Propositional modality", Deontic and Dynamic modality as "Event modality" (Palmer 2003:8, original indentation).

Palmer's constant, remarkable work on modality has continually added new lymph into modal studies and has influenced deeply most branches of language sciences. His studies are mines of insightful information on the particles. However, in the model and in the discussions there seems to be no indication as to whether, besides subjective inference, the conclusions conveyed by 'deductive' and 'assumptive' propositions may draw on statistical data and proven evidence of physical phenomena. In his classic text, Palmer touches on the reason for the exclusion of 'objective' functions in his analyses: "Alethic modality has been the main concern of logicians, but it has little place in ordinary language" (Palmer 1979:3). This argument is both sound and suggestive. By specifying the study domain, Palmer leaves open the possibility that, in realms where "… beliefs are grounded in both mathematically precise calculations of probabilities and proven evidence, modals may have other characteristics" (Lyons 1994:793).

Halliday ([1985] 2004) describes modal functions within his socio-linguistic theory of language according to which speech evolution involves a shift from 'congruent' to metaphorical representations. In light of this theory, Halliday terms *deontic* and *epistemic* modal categories as *modulation* and *modalization,* respectively. Thus, the *modulation* class is the 'congruent' semantic representation of modality since it performs the original or 'root' function of modals and carries *intrinsic* meaning. The *modalization* category is the metaphorical representation of modality resulting from a process of 'metaphorization' from the congruent expression to its abstract representation. Halliday defines the diachronic evolution from *modulation* to *modalization* as the fruit of a rhetorical technique or departure "… from the explicitly subjective orientation of the proposal or proposition, in the sense that the speaker or writer shifts the modal responsibility embodied in subjecthood to somebody or something else" (Halliday 2004:628).

The shift from congruent to metaphorical meaning is then presented as a product of grammar mechanics whereby 'subjective explicit' sentences containing mental verbs such as 'believe', 'suppose', 'think' are turned into 'objective implicit impersonal' expressions as follows:

> *I think Peter knows.* (congruent, subjective explicit)

becomes

> *Peter probably knows/Peter may know.* (metaphorical, objective implicit)

Halliday explains that while the first sentence states explicitly that the probability is decided subjectively, the second is a projecting clause which claims that the probability is objective (Halliday 2004:615). He comments that when speakers use the metaphorical version, (i.e., impersonal reference) they are using one "… of the many ways of expressing their opinions- or rather, perhaps, of dissimulating the fact that they *are* expressing their opinions …" (Halliday 1985:334, 2004:616). This theorem is supported by some context-free sentences which should embody the metaphorical shift proposed. Halliday concedes that the metaphoric mode expands the congruent mode significantly. But he restates his assessment about the

objective *epistemic* class: "Modality represents the speaker's angle on the validity of the assertion …", adding "…most of the objectifying metaphors are different ways of claiming objective certainty or necessity for something that is in fact a matter of opinion" (Halliday 2004:624-625).

The theoretical model proposed by Halliday is perceived as stimulating and in harmony with his model of diachronic language change from concrete lexical references to abstract grammatical metaphors. However, the descriptions seem to focus mainly on the performative functions of expressions and modals therein. No indications emerge on the role of reasoning supported by non-verbal codes, evidence of 'things' and contextual reference frames which can determine meaning in constative utterances and diagrammatic discourse (Austin 1975; Toulmin 1980). In terms of the linguistic model, the sentence reported in Halliday 1994:641:

> A magnitude-6 quake can cause severe damage|| if it is centered under a populated area.

can be framed as a 'metaphorical version' of a 'congruent expression'. Out of original context, the statement leaves unspecified the scale of reference and other parameters which can determine the quake's destructive effects. Direct experience with the aftermath of earthquakes of magnitude-6, on the Richter scale, in seismic zones, populated by ancient buildings, makes me hesitant about whether the modal 'can', in the expression, may be classified as a token of subjective belief ascription.

Sweetser (1998) proposes a description of modals which interweaves ideas developed by Palmer and Halliday with the concept of *force-dynamic* proposed by Talmy (Sweetser 1998). First, she outlines a diachronic perspective on the evolution of the particles' system:

> Historically, the English modals developed from non-modal meaning (such as physical strength or force e.g. OE *magan* "be strong", "be able") "*deontic"* modal meanings, and later still broadened to include the epistemic reading as well. (Sweetser 1998:50 - original parenthesis and indentation marks).

The pragma-linguist observes that *deontic* or *root* modals denote real-world obligation, permission, or ability whereas the *epistemic* modals denote necessity, or possibility in reasoning. She also mentions the ambiguity that lingers on decisions about the two sets of senses when analysing statements. Thus, she proposes a monosemous reading of the two canonical categories, and defines the epistemic class as "… an extension of the basic *root* sense … which is strongly motivated by the surrounding linguistic system" (Sweetser 1998:50).

In line with Palmer's proposal, Sweetser suggests a framing of the *epistemic* class as modality of propositions. Then, she expands her description with Talmy's schema which describes modals as bearers of force-dynamic influences. She explains that, in the domain of social interactions, *root* modals convey force dynamic relationship whereby 'may' implies "…. a potential, but absent barrier, 'must' a compelling force directing the subject toward an act" (Sweetser 1998:52). Sweetser explains that by way of metaphorical extension (metaphorization in Halliday's model) these implications filter into the *epistemic* class. In epistemic expressions, "…*may* implies absence of barriers in the world of reasoning from

premise to conclusion, *must* the available direct evidence compels me to the conclusion that …" (Sweetser 1998:59 - original italics).

In passing, Sweetser mentions Lyons's proposal to expand the *epistemic* class with other categories of meaning. She defines the suggestion as being useful but untenable, and supports her stance with the attested utterance:

> You must be Seth Sweetser's sister.

She explains that in this statement 'must' was triggered by the information on her name-tag, thus, the occurrence of the modal does not imply that 'real world' causes may have lead the speaker to utter the statement. She claims instead "…that he was obliged to *conclude* that it was true because the available informational premises caused him to reason thus" (Sweetser 1998:57 - original italics).

Occasionally, my surname, on conference name-tags, has elicited colleagues to address me with:

> You must be a relative of Quentin Tarantino.

In such circumstances, the amusing supposition was probably triggered by concomitant factors. Namely, the sameness of my surname and that of the famous film director, indications of my provenance, on my tag, foreknowledge about the director's Italian origins. I have never thought that the sole surname on my tag could have compelled colleagues to conclude that I was related to the American producer. Probably, the 'must' occurring in similar expressions subsumes speculations about probabilities rather than 'paralogistic' conclusions.

Sweetser mentions proposals which associate the *epistemic* category to acts of stating or binding. But she finds them 'not quite accurate'. She concludes her thought stimulating discussion by defining the force and barrier theory as a unifying view which proves epistemic modality to be: "… an essentially metaphorical application of our sociophysical modal concepts to the epistemic world" (Sweetser 1998:68).

The descriptive models briefly delineated above have contributed immensely to a better understanding of modal system. They have opened new perspectives on possible nuances of each element as well as motivated and influenced most of the research on the relative system in the literature. In its turn, each successive study has enriched the debate on fundamental aspects of the meaning making process (Hoye 2005). However, the models proposed appear to focus mostly on semantic features of the particles, in ordinary speech interactions, and to share a common line in qualifying the *epistemic* class as bearer of degrees of subjective beliefs. Undoubtedly, contributions from the individual speaker are fundamental in meaning construction and interpretation. But these complex processes depend on 'tacit knowledge' shared by interactants, the context of culture and situation, non-verbal codes and practical skills which partake in 'possible worlds' belief ascription (Austin 1970; Stalnaker 1999). More adequate analyses of modals might, thus, require taking into account all these epistemico-pragmatic factors as well as disciplinary matrices of scientific domains. Besides providing elements for the conceptualisation of modals as bearers of evidence-based knowledge, the expansion could shed more light on "… that class of beliefs which we are bound to adopt or not to adopt by our reasoning process" (Sweetser 1998:57-58).

3 The path from opinions to explanatory truths

Lyons (1994) discusses mental verbs, such as 'believe', 'suppose', 'guess', 'think', 'know', as fundamental concepts in the evolution of society and speech. But he specifies that among them only 'know' is a factive verb since it usually refers to direct experience of the facts reported. He qualifies the others as 'verbs of beliefs', and relates them to subjective appraisals, opinions and speculations about experience and events. He adds that belief verbs do not commit the users/reporters to validating their assertions since what one believes cannot be questioned and emphasises the demonstrable nature of beliefs in probative genres (Lyons 1994).

Specifically, in science, the word 'belief' carries different implications from those associated with the common sense notion. Quinn (2007) explains that when used in disciplinary context the term implies that the participants in the discursive interactions share the same commitment to the disciplinary programme. This includes theories, models and descriptions of physical phenomena, which can be challenged, but which pending further improvement, are taken as adequate explanations. The physicist adds that the expression 'scientists believe that' should convey the meaning: "Most scientists agree that the preponderance of evidence favours the interpretation that …. and furthermore, there is no evidence that directly contradicts that interpretation" (Quinn 2007:8).

Scientists have emphasised the evidence-based concept of 'belief' in scientific discourse since Galileo Galilei (1564-1642) opened the path to modern science. The scientist acknowledges the importance of sharing 'beliefs' for effective communication, but argues that in different context of culture and interests, the term-concept will bear connotations which draw on dissimilar reference frames. He points out, that in ordinary speech, 'beliefs' can thrive on feelings, guesses, hunches or suppositions which generally have a subjective basis. The interactants may have acquaintance with the object of 'belief' since they usually share conventions and other components of primary-culture. But they may not necessarily share concepts with identical quantitative reference frames. Galileo adds that the 'beliefs' sustaining ordinary conversation nourish on personal trust and everyday experience, thus, they require neither measurable quantities nor proofs for verification (Galilei [1615] 1957).

Galileo distinguishes the 'beliefs' driving ordinary speech from those grounded on religious teachings. First, he observes that common and religious 'beliefs' build on a form of persuasion based on rhetoric, evocative and emotive associations. Then, he observes that religious credos are grounded on the Holy Scripture, itself a body of 'beliefs' which thrives on the imagination and faith of its adherents. He defines this class of 'beliefs' appropriate aids for the human quest for a kind of truth which should need no tangible proofs for validation. Galileo separates the office of theology from that of science by specifying that the aim of: "… religious Scripture is to teach adherents how to go to heaven, whereas the aim of scientific pursuit is to understand how the heavens go" (Galilei [1615] 1957:212). He specifies that in order to achieve this goal, science cannot draw solely on first principles, it must build on observation of phenomena, measurements and verification while complying with nature which

> … is inexorable and immutable and does not care at all whether or not her recondite reasons and modes of operations are revealed to human understanding; she never transgresses the laws imposed upon her, or cares a whit whether her

> abstruse reasons and methods of operation are understandable to men (Galilei [1613] 2008:104-105).

Thus, to decipher the laws that govern natural events more than to believe one must want to know. In other words, Galileo proposes a direct approach to knowledge acquisition and expansion and separates beliefs based on fiducial acceptance of philosophic doctrines from 'beliefs' grounded on plausible arguments about verifiable facts and proven evidence.

In further defence of verifiable knowledge and 'demonstrative argumentation', the scientist contrasts the content and purposes of scientific discourse with those of literary genres "… in which the least important thing is whether what is written in them is true" (Galilei [1623] 2008:183). He acknowledges the importance of verbal communication and defines "… writing an invention stupendous above all others" (Galilei [1632] 1981:105). But he questions the trust which Peripatetic philosophers have in 'words writ on paper' and/or knowledge established by revered authorities. Galileo considers the teachings and ideas available in Aristotelian philosophy important, but in need of revision and updating. Thus, he argues that understanding nature requires constant systematic investigation with the aid of instruments, experimental activities and trained reasoning. The latter must rely on mathematical and geometric concepts and their relative representation procedures. In defiance of Peripatetic doctrine Galileo defines nature as a book which:

> … cannot be understood unless one first learns to comprehend the language and read the letters in which it is composed. It is written in the language of mathematics and its characters are triangles, circles and other geometric figures, without which it is humanly impossible to understand a single word of it …" (Galilei [1623] 1957:238).

The gist of this metaphor can be appreciated by recalling that scientists were groping in the dark about the characteristic of DNA until the geometric and mathematic structures of the molecule were devised and the chemical substance was experimentally reproduced and verified (Adler 2002).

The epistemology of science proposed by Galileo is actually a problem-solving activity where mathematic and geometric representations of natural phenomena are crucial. The diagrammatic characters of the two disciplines allow researchers to decipher and 'visualize' properties of physical processes and their inter-relations which cannot be perceived by the unaided senses. Moreover, the concepts and patterns of reasoning and representation of the two sciences are universal, immune to subjective interpretations, and always open to new improvements and applications (Hacking 1997).

In his treaties and letters, Galileo contends that no one should "… fix the limits for human mind … for no one can … assert that everything which is knowable in the world is already known" (Galilei [1613] 2008:104-105). He is aware of the multiplicity and complexity of nature as well as of the limits of human understanding. Hence, he suggests that scientific work must be considered a procedure of successive approximations towards better explanations. He observes: "There is no event in Nature, not even the least that exists, such that it will ever be completely understood by theorists" (Galilei [1623] 1957:258). Although confident that science will succeed in improving human understanding, Galileo cautions that scientific models and measurements will always remain approximate, however much

scientific instruments and procedures may be refined. Thus, he reminds fellow researchers that due to the complexity and mutability of nature and to the limits of both conceptual and technical tools, their knowledge and arguments can only be tentative and plausible: " … we must content ourselves with what little we can conjecture thus among shadows" (Galilei [1623] 1957:255).

Through his dialogues and demonstrations, Galileo advises scientists to be modest toward nature and to adopt a dialectical reasoning approach in their reports. The argumentation style proposed involves moving back and forth between contrary lines of reasoning using each to cross-examine the other (Finocchiaro 1980). Galileo's redefinition of belief content and his blending of concept and procedures of investigation from astronomy, physics, philosophy and mathematics with pattern of classical rhetoric established a form of knowledge and argumentation which thrives on verification and consensus and which is always tentative, probabilistic and corrigible (Polkinghorne 1998). In this perspective, the content of scientific discourse is stable, but not static. Modals serve to attenuate propositions and claims. They mirror both the complexity of natural phenomena and the limits of human understanding and research tools. Besides justifying the reporter's selection of one hypothesis as opposed to many other hypotheses that may coexist, they also bespeak the interconnection and openness of disciplinary realms (Hacking 1997).

4 Epistemico-pragmatic approaches to discourse and meaning

The implications carried by the term 'belief' in actual speech events has been a topic of debate not only in the sciences, but also in socio-scientific fields as semantics, philosophy and cognitive linguistics. Scholars of these fields highlight both the grounds of 'belief ascriptions and their relation to the meanings and uses of modal particles. They comment on the complementary nature of each particle and its adaptability to meaning strands consistent with participants, context, time, goals and evidence supporting argumentation and claims.

In particular, Stalnaker (1999) provides a pragmatic frame of the concept of belief and identifies its main components as:

> … the person reporting the belief, the content of the belief, the nature of the relation between the believer and the content that constitutes its being the content of his or her belief, the possible situations and time framing the beliefs reported (Stalnaker 1999:21).

The cognitive linguist explains that all these elements interrelate and should not be neglected when characterising 'belief' content. He frames belief analysis as an epistemic process which requires taking into account the 'mental states' of the interactants and the 'possible worlds' or the reference frames they must share for successful communication. Stalnaker cautions that his formula for belief ascription should be considered functional only when characterising 'beliefs' related to mental states engaged in ordinary speech. In such contexts beliefs are 'two dimensional' and, thus, narrow for multimedia discourse which draws on verbal and non-verbal codes (Stalnaker 1999:26). After qualifying belief ascriptions according to the tacit knowledge shared by interactants and relative semantic, epistemic and pragmatic components, Stalnaker, points out that in science: "… one may explain concepts, not by defining them, but by using them to account for phenomena" (Stalnaker 1999:46).

Stalnaker emphasises the pragmatic nature of modal meaning:

> Modal terms are notoriously dependent on context for their interpretation. For a sentence using *can*, *may*, *must* or *ought*, to determine a proposition unambiguously, a domain of "all possible worlds" must be specified or intended (Stalnaker 1999:35).

Thus, he argues that meaning is context-specific and contingent to circumstances, time and space, and defines unsound the practice of assigning modal functions to context-free statements. In this perspective, analyses of modal expressions, whether in general or in specific context of situation and culture, should be in light of cognitive, pragmatic, ethical and contextual strands shared by interactants. The interaction between these elements render meaning "… consistent with the speaker's knowledge, or with some set of presuppositions, or with what is morally right, or legally right, or normal, or what is within someone's power" (Stalnaker 1999:36). In turn, this complex interrelation constitutes the 'possible worlds' or shared 'mental spaces' contributing to effective communication. Therefore, the cognitive linguist proposes a framing of beliefs and modal categories attentive to the conceptual worlds, manual skills, presuppositions, extra-linguistic knowledge shard by the interactants.

Stalnaker's arguments about beliefs and modal categories is complemented by proposals of other eminent scholars as Austin (1970, 1975); Lyons (1994) and Toulmin (1980). The discussants argue for the rediscovery of pragmatic and dialectical elements which link thought, actions, words and meaning to the physical and disciplinary worlds. The holistic approach to communication study they sustain would require that sentences and their components be analysed in relation to: external reality — the world of objects and events; internal reality — the speaker's own world, intentions, experiences, the normative reality of communities: shared knowledge, values, norms, and rules (Habermas 1979). This approach would favour a better understanding of both the relationship between language and the systematic investigation of natural processes. But it would also reveal the influence that the understanding of nature can have on the creation, organisation and meaning of verbal patterns (Hacking 1997).

Lyons (1994), whose seminal study on the semantic of modal categories has inspired the work and arguments of the 'naïve realist' group (Coates 1983; Nuyts 2001; Papafragou 2006), proposes that linguistic studies should progress from micro- to macro-semantic descriptions. This approach would encompass grammar-semantic, pragmatic and cognitive strands of communication. In his discussions he suggests that the process which can lead from ordinary language use to expertise in field-related discourse production and interpretation depends on academic training, cumulative knowledge, individual interests, and acquired practical skills. Thus, Lyons distinguishes between notions related to subjective opinions and imaginary situations, which drive 'everyday affairs', and concepts framing facts, conditions, and situations which can be observed and measured in the physical world.

Lyons divides propositions into two groups "… one having a neustic, 'I-say-so', component, the other a tropic, 'it-is-so', component" (Lyons 1994:799). He associates the former with subjective inferences and statements of opinion, which are 'indisputable'; the latter with contingent statements of facts which can be both questioned and demonstrated. Lyons defines differences in modal descriptions available in the literature as 'largely terminological'. He

attributes the hesitancy to extend modality categories beyond the prototypical domains to the fact:

> … that few linguists have even considered the possibility that epistemic modality could be anything other than a matter of the speaker's attitude towards the propositional content of his utterance … and … take it for granted that modality is subjective, in this sense" (Lyons 1994:805).

Thus, he proposes widening the *epistemic* modal category to include evidence-based and truth-conditional propositions. To this purpose, he delineates the difference between the concept of 'truth' and that of 'belief' by defining 'factive', 'non-factive' and 'contra-factive' propositions. Factive utterances commit the speaker to the truth of the proposition since they have "… an 'it is so' component that is qualified with respect to a certain degree of probability …" (Lyons 1994:800). Non-factive "… utterances are subjectively modalized, they relate to verbs like 'believe' or 'think', which commit … the speaker to neither the truth nor the falsity of the proposition expressed by its complement clause …" (Lyons 1994:795 - original indentation). Contra-factive utterances "… indicate the speaker's commitment to the falsity of the proposition expressed … and include … wishes and counter-factual conditionals" (Lyons 1994:795).

Lyons proposes an approach to the description of epistemic modals which combines linguistic, logic and pragmatic functions that the relative particles can perform in discourse. In light of these functions he introduces the concept of *alethic* modality and explains that this category of meaning conveys apodictic probability, possibility and conclusions. These connotations are grounded in either direct observation or confident inference from clearly demonstrable facts. Lyons details the multiplicity of meanings entrusted to modal elements and relates them to statistics and "… necessary or contingent truth of propositions … regarding objective intrinsic characteristics and variability of processes and events in the physical world" (Lyons 1994:791). He specifies that the epistemic category should be grouped into two sub-classes: one related to 'reasoning about propositions', the other to 'reasoning about the knowledge' conveyed by propositions. The first which he terms "… *subjective* epistemic modality concerns the qualification of the performative component of the utterance" (Lyons 1994:808). This category is relevant to ordinary speech, where there is usually no need to ground modal meaning on verifiable quantities, measurable dimensions and scalar degrees. Lyons names the second sub-class '*objective* epistemic modality', and explains that the meanings of the relative particles are governed by the factuality of the propositions. These refer to knowledge and evidence supported by verified models, precise measurements and reliable statistical data. Therefore, *alethic* and *objective* functions are relevant to scientific discourse where arguments are grounded in models of natural phenomena, controlled data of events, mathematically precise calculations of probabilities (Lyons 1994). The authentic statements which follow seem to embody well Lyons' distinction between factive and non-factive utterances as well as to sustain his arguments for the widening of modal functions.

During a visit to an art exhibition in Rome, an admiring visitor comments:

> 1) Caravaggio's Bacchus is a live representation of the delights that a good wine can give.

This utterance fall well within the 'I say so' or 'non-factive' proposition class. '…the delights

that a good wine can give' express the personal synaesthetic sensations of an art and wine expert. The statement is imbued with *subjective* perceptions grounded on a sort of transfer whereby the modal 'can' relates to the sensations of the human subject rather than to the functions of the inert substance.

During an informal meeting, a friend suffering from rheumatisms mutters:

> 2) Tomorrow, it will rain.

The utterance is a likely complaint due to weather-related physical symptoms. Its association with recurrent body conditions gives the expression objective contours. Yet the modal 'will' bears *subjective* inference with scarce predictive power and no indication whatever of the nature of the precipitation, or the space/time extension of the event. As observed by Lyons: "… there is no reason to believe that either subjective or objective epistemic modality, in non-scientific discourse, is grounded in mathematically precise calculations of probabilities" (Lyons 1994:793).

Reported by a meteorologist: 'Tomorrow, it will rain.' is a factive statement. The forecaster draws on data from weather satellites, zonal humidity and temperature measurements, calculations of wind direction and intensity. The indications will also base on mathematical models and information about cloud types and reference scales of possible changes in the atmosphere (Iribarne & Cho 1990). Through elaboration and correlation of data, any member of the scientific community may predict the precipitation consistency, duration and extension with a good probability of being right. In the scientific statement 'may/will' signal *objective*, deductive and deductive conclusions based on calculations and tempered by knowledge of the fickleness of natural phenomena.

The following fragment is from a report on the mechanics of the fracturing of glass caused by the interaction between silica and water molecules:

> 3) The chemical reaction between the silica and the water can reduce the amount of energy that must be supplied to make the crack extend (Michalske & Bunker 1987:81).

The statement describes the results of a chemico-physical interaction between the atomic structures of the two substances. In set conditions, this process, can initiate the cleaving of the silica atomic bonds and establish the fracturing mechanism. The atomic structures of both compounds and the mechanism setting out the disruption can be observed and recorded by Fourier-transform infrared radiation and spectroscopy. The phases of the event can then be modelled by mathematical and diagrammatic means, replicated and verified in experimental conditions (Michalske & Bunker 1987). Therefore, the modals in the text do not signal willingness and sensations of the two inert substances, but *alethic* relationship between ascertained chemico-physical elements and their interactions in nature.

After having characterised the semantico-epistemic and pragmatic elements distinguishing the *objective* modal subclasses, Lyons recalls the possible diachronic evolution of modal meaning from *root* to *subjective* epistemic. However, he emphasises the transition from lay-beliefs to knowledge-based inferences which are grounded on systematic investigation of physical phenomena, dialectical reasoning and verifications of claims. He considers *subjective* and *objective* functions of modality as latent and intermeshed in the production of empirical

propositions.

> Objectively modalized utterances … can be described as having an unqualified "I-say-so" component, but an "it-is-so" component that is qualified with respect to a certain degree of probability … (Lyons 1994:800, original indentations).

Lyons cautions that in constative speech domains, subjective interpretations must be filtered through objective, quantifiable evidence of knowledge and facts in order to free propositions from possibilities and necessities created by acts of human will. He restates that the 'objective' modal classes convey "… physical possibilities and necessities performed by agents external or internal to the physical system within which these possibilities and necessities operate" (Lyons 1994:844). Lyons' enlightening discussions also teach that in scientific discourse modals serve to attenuate not only concepts, actions and facts, but also the speaker's confidence in what is reported:

> the very fact of introducing 'must', 'necessarily', 'certainly', etc., into the utterance has the effect of making our commitment to the factuality of the proposition explicitly dependent upon our perhaps limited knowledge (Lyons 1994:793).

Thus, the semanticist descriptive model is attentive to disciplinary knowledge, ontology, techniques of investigation, and verification of evidence as relevant to scientific progress. His observation that, in scientific discourse, *subjective* strands may intermesh with but must give way to *objective* and *alethic* connotations seems, in fact, to mirror well Einstein's teaching:

real knowledge is a combination of external evidence and internal response to that evidence; it cannot spring from experience alone but only from the comparison of the inventions of the intellect with observed fact (Einstein 1934:27).

Austin (1975) considers linguistic forms necessary, but not sufficient to establish appropriate communication. He acknowledged the usefulness of sentences devised for grammar-logic studies, but defines them *parasitic* upon normal use and 'void' of actual meaning (Austin 1975:137). Thus, he proposes a pragmatic approach to language study which accounts for the role that speakers, conventions, rituals, social rules and actions can have in "*uttering words*" for valid purposes. In this perspective, he groups utterances into two broad categories termed: 'performatives' (operative), and 'constatives' (descriptive) speech acts. In the former class, language serves to perform actions, in appropriate socio-cultural contexts and circumstances; in the latter, it serves to make statements about facts, events, processes which can be proven as true or false.

Throughout his discussion, the philosopher of language emphasises the dependence of verbal construct on context of situation, socio-cultural norms, actions and purpose of speech events. He specifies the elements which can contribute to the understanding of intended meanings and favour recognition of inter-subjective validity of claims by arguing that:

> … it is always necessary that the *circumstances* in which the words are uttered should be in some way, or ways, *appropriate,* and it is very commonly necessary that either the speaker himself or other persons should *also* perform certain

> actions, whether 'physical' or 'mental' actions or even acts of uttering words (Austin 1975:8 - original italics and single indentations).

Austin's holistic approach to discourse analysis comes through his proposal that: "The total speech act in the total speech situation is the *only actual* phenomenon which, in the last resort, we are engaged in elucidating" (Austin 1975:148 - original italics). He explains that actual speech events involve complex cognitive activities whereby constative propositions can overlap with performative statements. At the same time, he emphasises the inadequacy of pure grammar-semantic analysis of speech since without reference to pragmatic strands of the content " … one cannot always answer in a simple manner whether it is true or false" (Austin 1975:143).

Austin observes that the 'truth' engaging human search is relative to intent, context, time and purposes of activities which influence the meaning of utterances. Thus, he proposes a model of analysis attentive to foreknowledge of facts, at the time of utterance, features of the context and act performed, purpose, interest and intentions of the interactants (Austin 1975:145). Even though recognising the fundamental role of ordinary language in the evolution of knowledge, Austin calls attention to the epistemico-pragmatic factors which differentiate ordinary from scientific speech:

> … in spite of the wide and acute observation of the phenomena of actions embodied in ordinary speech, modern scientists have been able, …, to reveal its inadequacy at numerous points, if only because they have access to more comprehensive data and have studied them with more catholic and dispassionate interest than the ordinary man… (Austin 1970:203).

He adds that in scientific discourse constative speech acts are backed by objective quantitative and qualitative data which commit the speaker to the truth of the claim and comments that the same specificity is not required in the perfomative utterances populating ordinary speech.

In "Ifs and cans" (1970) Austin suggests that modals always bear 'iffy' connotations. He advises that particles should not be constrained within grammar-semantic schemata since "… their interpretations will be clear from the context" (Austin 1970:212). Thus, he argues that, according to context, each modal can imply: condition, doubt, consequence, stipulation, alternative choice, possibility, right, legitimacy, feasibility, practicability, supposition, opportunity, skill, motive, ability, action. In actual speech these implications are often interdependent:

> 'He has the ability to do X' simply means that 'If he has the opportunity and the motive to do X, he will do X' (Austin 1970:227 - original indentation).

Austin concludes his insightful discussion on modal meaning by suggesting that grammar study could become: "a true and comprehensive science of language by joining labours with philosophy and the mathematics as witnessed at the birth of science" (Austin 1970:232).

Toulmin (1980) relates to Lyons's and Austin's pragmatic perspective on language and modality and suggests that the function of each particle should be analysed in consideration of the concepts of *force* and *criteria*. He terms *force* the basic logico-semantic meaning ascribed to the grammar forms, and defines *criteria* as "… the standard grounds and reasons by

reference to which we decide in any context that the use of any particular modal term is appropriate" (Toulmin 1980:30). The philosopher of science then specifies that *force* is a field-independent semantic dimension of modals (*denotata*), whereas *criteria* is field-dependent (*denotatum*). Thus, the *criteria* components relate *epistemic* modals to pragmatic elements including intentions, purposes, rules, conventions and knowledge patterns of a given speech community. In other words, *criteria* embody the extra-linguistic declarative and procedural components of multimedia discourse which can regulate the coding and interpretation of discourse.

Toulmin details the *criteria* implications conveyed by modal particles by considering the functions of 'can' in *epistemic* expressions. First, he defines the *force* or grammar facet of this particle as constant and generally implying possibility and probability of events, actions, activities in affirmative, and impossibility in negative utterances. Then he demonstrates that in different contexts of situation and culture, the *criteria* of use will determine whether 'can' refers to human physical or cognitive ability, dimensional capacity, linguistic, and social appropriateness or impropriety, moral obligation, legal rules, mathematical certitude, and physical properties.

The philosopher of science points out that whether something is possible, appropriate or impossible can only be decided in relation to rules, conventions and knowledge patterns of activity fields. He comments that the problems concerning physics have little in common with those of either team-selection, aesthetics, or poetry. Thus, he emphasises the role of mathematical and physical evidence in deciding the choice and meaning of each particle in scientific discourse. Toulmin's arguments seem to reflect both Lyons's and Austin's ideas on the subject:

> Our probability-terms come to serve, therefore, not only to qualify assertions, promises and evaluations themselves, but also as an indication of the strength of the backing which we have for the assertion, evaluation or whatever. It is the quality of the evidence or argument at the speaker's disposal which determines what sort of qualifier he is entitled to include in his statements: whether he ought to say, 'This must be the case', 'This may be the case', or 'This cannot be the case'; whether to say 'Certainly so-and-so', 'Probably so-and-so', or 'Possibly so-and-so' (Toulmin 1980:90).

After dealing with probability particles, Toulmin discusses the organisation of a scientific report, which he terms 'demonstrative argumentation'. The layout proposed consists of a set of macro-linguistic, semantico-pragmatic structures whereby each component integrates and verifies the content of the other. In the analytic model, the claim or thesis poses the problem and anticipates its solution. The concurring parts firstly provide background information; secondly highlight new possibilities for improvement of data and understanding; thirdly; substantiate the evidence supporting the results reported. In conclusion, the argumentation deploys through a comparative analysis between the novel hypothesis, experimental results obtained and the findings of previous reports. Thus, the epistemic process activated through the presentation involves a critical evaluation of the congruence between the predictions motivating the research and the actual results obtained. In the report, the orchestration between conceptual and rhetorical patterns serves to activate a heuristic process which co-involves the writer and readers in a dialectical interaction. In the intellectual and dialectical tension that establishes between the interrelated sections, the source and addressees, modals

have a pivotal role and influence both the argumentation and interpretation processes. (Toulmin 1980).

Through his articulation of the report layout and content, Toulmin emphasises the apophantic nature of scientific argumentation, its progressive vocation and its foundation on cumulative knowledge, mathematical and factual evidence, doubt, questioning and verification. He observes that linguists and philosophers of science tend to neglect the role that mathematics and diagrams have in scientific discourse deployment and interpretation: "…the bare form of words on which these scholars focus on can only lead to a naïve interpretation quite false" (Toulmin, 1969:25). Toulmin then demonstrates that mathematical and diagrammatical patterns are integral parts of scientific research, reasoning, and argumentation processes. Thus, he concludes that better understanding and more effective models of scientific argumentation may follow if the analyses contemplate also the influences of non-verbal codes on the conceptual, procedural, and linguistic components of discursive practices.

The foregoing discussions propose that discourse and meaning analyses should be addressed in light of the multidimensional relationships characterizing the physical world, technological innovations, inter-subjective knowledge, and representation patterns which can influence the sensory and intellectual spheres of individuals. The arguments provided demonstrate that modal meanings and belief ascriptions depend on proven evidence, purposes, interests and skills shared by communities of practice. Thus, they suggest that semantico-pragmatic strand issuing from these concomitant elements should be part of multimedia discourse descriptions. Besides opening new perspectives on meaning, the more comprehensive analyses would allow a better understanding of how the particles can contribute to research activities and discourse processing consonant with research field epistemology.

5 Meaning and the pursuit of science

As it is well known, science is a pan-cultural enterprise whose roots trace back to the efforts made by ancient people to understand and explain natural phenomena perceived by the unaided senses. The Chinese, Egyptian and Babylonian civilizations observed astronomical phenomena for their religious worship, for deciding routine affairs of life and for determining when to plant and harvest. They tracked the passing of time by the daily movement of the sun across the sky, while they reckoned the time of the year by either the phase of the moon or the seasonal movement of the constellations. Their observations of the heavens aided them in setting calendars, in surveying the land and in navigating on both land and sea.

Babylonian astronomers observed astral motions primarily to draw predictions about human destinies and/or natural events. Despite the primitive equipment available, they made very careful records of the phenomena visible in the heavens. They used abstract thought and devised a number system based on 60 and a system of calculation which later led to the development of algebra. The number system devised by Babylonian astronomers is still present in our units of time and the pseudo science of astrology they contrived holds sway even in post modern societies.

The Egyptians applied heavenly occurrences to their religion and prophesies, but also used the information for practical use in planning the layout of the pyramids. In developing the relative projects they displayed great technical skills as well as competence in systematic mathematics and geometry. Babylonian and Egyptian astronomers observed and charted the heavens

primarily to seek solutions to practical problems. They did not the observations to derive scientific laws and principles.

The Greek cultures, which followed, rather than practical problems tried to solve intellectual questions regarding matter and its origin. In this effort, Athenian schools of philosophy fostered the birth of deductive and inductive reasoning. One of the most brilliant intellects in all human history, Aristotle (384-322 B.C.), was the first to argue that principles must be compatible with observation and cannot be based on abstract reasoning alone. But he considered mathematics and geometry technical disciplines, thus inappropriate for philosophers who study physics and cosmology. Aristotle's theories of the physical world maintain that the sun and the planets were perfect, incorruptible spheres which revolved around the static Earth; that the speed of falling bodies is determined by their weight and that time is cyclical similar to biological processes as the blood circulation. Aristotle's ideas about 'how the heavens go' where incorporated both into Ptolemaic astronomy and into religious and Peripatetic teachings. This led to the stagnation of scientific research and sustained the conceptual and cultural belief knots which Galileo set out to disentangle.

Galileo established the scientific method by direct observation of physical phenomena, with the aid of instruments, and by espousing concepts and techniques of investigation of both the mechanical and the philosophical sciences. This blending of knowledge and skills supported his experimental activities by which he discover the isochronism of a pendulum, the parabolic trajectory of a projectile, the moon's mountains, Jupiter's satellites, Venus phases. These discoveries shook Aristotelian beliefs about heavenly perfection. Galileo also discovered the dependence of motion on time and was actually the first researcher to time physical events and to establish that motion is time dependent. In the process, he invented metric-time and made time the fourth dimension of scientific measurements and investigations (Szamosi 1986). Thus, he influenced a revolution in the conceptualisation of nature and man which paved the way to the discovery of more and more complex patterns of the physical world.

Galileo presents his findings by interweaving verbal structures with mathematical, geometric, and philosophic concepts. He provides illustrations of the objects observed and of the instruments and procedures used in the research activity. This allows both the observations made and reasoning strategies adopted to be: "… manifest to the senses as well as the intellect of thoughtful men" (Galilei [1610] 1989:36). This combination of codes and operational-steps is a resource for

> … formulating degree, quantity, gradation, continuous change, continuous co-variation, non-integer ratios, varying proportionality, complex topological information of relative nearness or connectedness, or nonlinear relationships and dynamical emergence which gives meaning a topological dimension (Lemke 1998:87).

In other words, Galileo established multimedia discourse whereby each code serves to visualise facts and concepts and to aid peer-experts to verify claims, and draw novel inferences leading to further investigation of the facts observed. Galileo claims that his contributions to science are modest, but indicates also his trust in future knowledge advancement. Thus, he emphasises the kairotic nature of scientific discourse and procedures:

> There have been opened up to this vast and most excellent science, of which my work is only the beginning, a gateway and a road by which other minds more acute than mine shall penetrate to recesses still deeper (Galilei [1638] 1989:190).

The history of scientific advancement teaches that new hypotheses and models can bring about new discoveries and representations of natural processes and objects with consequent novel beliefs based on verified knowledge (Quinn 2007). In fact field-related discourse domains progress through a constant flux of review and updating of concepts, techniques, instruments and terminology. Scientific communities are actually engaged in a constant search:

> … of congruence between the categories of our symbolic system in our minds, the signs of the linguistic system and the properties of the material world. The congruence between the meaning in our minds and the meaning in the minds of others is negotiated through agreement over the selection of appropriate signs and symbols. A negotiated inter-subjectivity is possible through the material changes we express in the world as we interact (Monk 1994:130).

At present, scientific knowledge differs from common sense understanding and Aristotelian ideas in so far as it studies natural phenomena by stratifying them into a set of three realms. Each realm is constellated by numerous disciplines and sub-disciplines with their own theoretical models, languages and diagrammatic patterns.

> **Realm 1** is the realm of the directly accessible material world of objects and properties that can be sensed unaided.
> **Realm 2** is the realm of those things which can be accessed through instrumentation. These are initially proposed through logical reasoning.
> **Realm 3** is the realm of those things which are beyond sensory experience and instrumentation but are accessed through logical reasoning alone (Monk 1994:131).

The historic and epistemico-pragmatic evolution from realm one to the more complex realms of observation has required time, dedication, development of new geometrico-mathematical models, instruments, and representation patterns by members of different cultures who belong to disciplinary communities.

The differences between the grounds of beliefs populating ordinary speech and those governing the 'possible worlds' of the three realms can be appreciated by reflecting on the text-fragments which follow. The first three samples belong to a medical review report on chronic pelvic pain. The reporter analyses data from 79 longitudinal-based clinical studies involving a population of 1200 patients suffering from the syndrome. The review includes observations by clinicians, surgeons, psychologists and pharmacologists along with descriptions of symptoms by patients. The paper presents pain intensity scales and maps, diagrams. It details physical examination procedures, diagnostic tests and therapies elaborated by physicians in the effort to cure the patients. The statistical data quoted concern results obtained in 40 years of controlled and follow up studies. In spite of the trials and efforts, clinical therapies and surgical interventions appear to have had very limited success.

> (a) Treatment of chronic pain may consist of two approaches. One is to treat chronic pain itself as a diagnosis, and the other is to treat diseases or disorders that might be a cause of or a contribution to chronic pelvic pain (Howard 2003:6).

Text (a) opens the discussion and feature two modals *may* and *might,* respectively. In this context, more than possible 'uncertainty' *may* indicates alternative choice and/or disjunction. It also embodies a deductive conclusion since it relies on verified medical experience, recorded response by patients and instrumental results. The tentative/doubtful *might* implies uncertainty which linger on both the causes and treatment of the disease. The modal relies on deductive and inductive inference, doctors and patients reports and correlations between statistical data of single and cohort studies which "… show differing results and thus more evidence is needed" (Howard 2003:7). Rather than beliefs, the two modals convey dialectical reasoning, criticism and frustration due to the poor results obtained (only from 15% to 26% of the patients report temporary relief from the pain, whatever the approach and therapy).

In another section of the review the author observes:

> (b) Surgery for advanced stage endometriosis can be challenging, tedious and frustrating, and in many cases cannot be performed laparoscopically. Thus, it may not automatically follow that these data are applicable to surgeries for patients with stage IV disease (Howard 2003:605).

The *can* in this fragment, rather than abilities/capabilities, implies 'at times' as well as unsatisfactory results. The *may* has the connotation of 'at times' as well as implication that the invasive operation is not guaranteed to be successful. Again these connotations are backed by statistical data on the effect of laparoscopy on the patients subjected to the operation. The modals in the expressions have little in common with untutored-subjective opinions. They relate to experience, statistical data, instrumental skills and experience common to the peer-experts who will be reading the report.

The data discussed in the review-report lead to final remarks with modals which embody comment/advice/contingent conclusions and which imply also the intellectual and human commitment of clinical researchers. The clinical reports overviewed suggest the conclusion: "Diagnosis and treatment can be complex, and the goals of treatment must be realistic". These crude remarks are however tempered with optimistic anticipations of probable scientific advancements: "… with future research, the psychoneurological dysfunctions responsible for chronic pain may be identified leading to definitive, curative treatments" (Howard 2003:608). The report data and comments on the disease are meaningful for the intended readers since they share disciplinary knowledge with the review author from experience accumulated both during their medical training and practice and while reading the report. The text and comments tentative bent represents well the complexity of the medical sciences due to the manifold differences between human individuals. The report is interdisciplinary, and relies on shared in-group codes and mental spaces of the macro-realm (Fauconnier 1994).

Scientific concepts may recur in different contexts and in conversations among people with different cultural backgrounds. The following observation may occur in either everyday or specialist speech events:

(c) Oil will float on water, thus, any leak in the offshore oil well can be readily detected on the surface of the ocean.

A lay person making the above comment may ground the utterance on direct experience with the observable event, on media reports, and/or may also have basic-scholastic notions about the behaviour of liquids due to differences in their density and miscibility. If based only on the direct observation of the phenomenon, the modal *will* may be classified as due to 'presumptive' or inductive reasoning associated to conditional statements. If the modal concerns the physical properties of the two substances then it relies on deductive inference: cause/effect relationship due to the different densities of the two liquids causing the buoyancy at a specific temperature:

salt water density 1.030 g/cm^3 at 4° C, spill oil density 0.9942 g/ cm^3 at 4° C

A geo-technician making the same claim may certainly draw on common experience of the process, but he will also have detailed knowledge of the properties of the fluids for having measured their density with appropriate instruments. He has investigated the behaviour of liquids in laboratory experiments and carried out measurements of the phenomenon in different circumstances. His understanding will also be backed by interdisciplinary studies and visualisation techniques. In the specific case, the scientist will rely on pragmatic presupposition about the molecular chemistry and structures of substances and their influence on polarity and reciprocal solubility of liquids. This knowledge includes conceptual patterns, statistical data, diagrammatic representations of phenomena, manual and verbal skills developed during academic training and work experience. It will serve to describe and predict the behaviour and properties of liquids in set conditions and can be applied to solve possible problems in novel situations.

The mathematical models and the physical properties of the substances, familiar to the expert, constitute the extra-linguistic frames of reference which codetermine the choice and denotation of the modals in this statement. Whether reported by a lay person or a scientist the *will* and *can* in the text have *alethic* function since they refer to indirectly observable physical properties of the liquids and techniques which are independent of personal beliefs and linguistic system features. The scientist's utterance has also *objective* nuances due to the contribution of statistical calculation and of three-dimensional diagrammatic representation of molecular structures which he can reproduce.

The concepts of *objective* and *alethic* modality may be more suitable than *that* of subjective beliefs in framing the modal of statement (d), in actual context of situation and culture:

(d) An earthquake of magnitude 5.9 (Richter scale) can cause severe damage, if its epicentre is close to a populated area.

If the reporter of the (d) is a lay person, the utterance may express a personal evaluation grounded on direct experience with the dramatic event and/or media-acquired information about earthquakes magnitude and effects.

If the reporter is a geophysicist, he may be making a prediction of a possible event. In this context, the meaning of the modal will subsume knowledge about possible magnitude (**M**) and intensity (**I**) of earthquakes. The scientist can calculate **M**, or energy released at the

source, through a mathematical formulae such as:

$$\mathbf{M} = (log\mathbf{M_0})/1.5\text{-}10.7$$

where $\mathbf{M_0}$ is the scalar moment in dyne-cm. He can also calculate the **I**, i.e., the violence of the earth motion near the epicentre, by relating to the Mercalli scale. The scientist will also know that damages may depend on other characteristics of earthquakes, namely, location and depth of their focal point, direction of the energy propagated by the seismic waves, structure of the rocks and soil subjected to the event. Moreover, predictions of earthquake consequences on populated zones will involve knowledge of the age, materials and structural frames of the buildings and infrastructures of the possible areas affected.

Therefore, the scientist's statement would be grounded on cumulated disciplinary knowledge. It would also draw on statistical data, determined from measurements collected by seismographs, equations and diagrams, for establishing the time of occurrence of an earthquake, seismic wave amplitude and stress, wave front advancement and so on (Lowrie 2002). The geophysicist can also refer to images collected by satellites, tectonic maps and other contributions from interdisciplinary research fields. All this data builds on mathematical models, instrumental measurements, scales of reference, and representation skills of disciplinary domains. The geophysicist's reference frames are patrimony of a specific scientific community and should be considered independent of subjective beliefs and linguistic system conventions (Widdowson 1979).

When an earthquake has already occurred, the scientist will use disciplinary knowledge and techniques to investigate and explain what must or might have been the causes for the damages and loss sustained. The information on which he will bases his explanations are now of a different kind, nonetheless, they should not be confused with speculations based on untrained observations and opinions. The earthquake causes are sought by analysing different data and 'signs' so as to formulate of an evidence-based explanation. The procedure followed to build more reliable evidence goes through approximations from inferences which are well illustrated by Austin definition of scientific evidence:

> The situation in which it would properly be said to have evidence for the statement that some animal is a pig is that, for example, in which the beast itself is not actually on view, but I can see plenty of pig-like marks on the ground outside its retreat. If I find a few buckets of pig food, that's a bit more evidence, and the noise and smell may provide better evidence still. But if the animal then emerges and stands there plainly in view, there is no longer any question of collecting evidence; its coming into view doesn't provide me with more evidence that it's a pig, I can now just see that it is (Austin 1962:115).

The complexity and dynamicity of natural phenomena, will rarely, if ever, allow scientist to have a complete and definite picture of events and processes. Therefore their explanations will remain provisional and in terms of probability of occurrences and plausibility of reasoning aided by energy scales, computation and correlation of recorded data.

The previous examples relate to processes whose apparent results can be observed with the naked eye, but whose causes can be determined and explained with the aid of instruments and mathematical models. Science also studies the sub-microscopic world which is 'beyond

sensory experience' and which can be access either through reasoning and mathematical models, or through very powerful instruments. An example of this reality is the process of conformational rotation which can occur spontaneously in molecules with single-bonded carbon atoms and is studied in chemistry, biochemistry and pharmacology. The content and modals of text (e):

> (e) Single-bonded molecules can rotate about the sigma bonds holding the atoms together, but this rotation cannot occur in double-bonded molecules. The additional pi bond firmly fixes the atoms with respect to one another, there can be no free rotation about the carbon-carbon double bond (Amend et al. 1989:424).

will thus be meaningful to experts of the specialist fields, but may convey little meaning to people outside these disciplines. In chemistry and bio-chemistry, the statements become meaningful owing to observations and comparison of natural phenomena such as light absorption and reaction of different substances to heat recorded in disciplinary studies. This knowledge has to be coupled with knowledge about the structure and behaviour of actual molecules in set conditions, and with models of representation and conceptualisation shared by the members of disciplinary communities. From academic training and observation, members of research communities know that the first statement is true to fact when:

1) a single (or sigma type) bond links two molecular fragments;
2) impediments to the rotation due to volume and size of the fragments (steric hindrance) are negligible;

They are also aware that:

3) in the presence of double bonds and steric hindrance, rotation can occur when the molecule is subjected to high temperature, UV light, or enzymatic action.

The process is usually represented through a diagram which shows a graphic of both the rotation occurring in the bond of the atoms, the different energy levels and the corroborative conditions required for the event to occur in specific substances. In the description of the rotation process, the language structures vehicle factual information. They relate to thought, visual patterns, manual skills, and verbal and non-verbal codes acquired through disciplinary training. The graphic representation of the process and energy levels visualises a possible behaviour of molecule fragments in specific and well-documented conditions and leaves the observation open to other possible interpretations.

Scientific researchers have evidence of the chemical and physical properties of each substance and under what conditions the phenomenon investigated may, can, will, must occur. Thus, they also know in which context the phenomenon visualised in the diagram and the description provided in the text are appropriate and true-to-fact. The epistemico-pragmatic strands carried by the modals allow researchers, in the specialist fields, not only to imply degrees of possibility and probability associated with the event described, but also to use this knowledge for valid applications of the chemical interactions to solve problems in chemistry, biochemistry, pharmacology and in other disciplinary fields.

The properties of conformational rotation have been studied for long time, thus, the researchers have substantial evidence on the phenomenon for reliable inferences about the

event. In frontier research field as biochemistry and genetics the evidence is still insufficient thus the modals *may, might* and *should* refer to uncertain possibility/probability, expectation (Adler 2002).

To a lay speaker, the content, concepts and events in text-fragments reported above may be only partially accessible, whereas to the initiated, they indicate physical conditions, dynamics of tectonic plates and properties of substances at subatomic levels. The researchers working in the various fields of science will know how to intervene in posing and solving problems about organic function/dysfunction or about phenomena of the natural world (Hacking 1997). They are familiar with disciplinary rules and techniques and also experts in interweave mathematical, motor-visual, diagrammatic, and verbal patterns, in order to illustrate both the phenomena investigated and the reasoning activities engaged in the inquiry process. This combination of codes and actions not only makes the evidence presented independent of the idiosyncrasies of individual inquirers, but also equips scientific prose with topological dimensions. The latter contribute to rendering the content accessible, verifiable and open to change. In other words, the open-ended nature of content matter, tools of investigation and representation strategies make the discourse domains inter-subjective, cooperative, and progressive, along a series of approximation to more reliable truths. Thus, it co-determines the meaning of concepts, terms and modal elements (Lemke 1998).

6 Conclusions

The foregoing discussion has presented proposals and evidence which appear to support the hypothesis that more adequate analyses and descriptive models of multimedia texts may require widening both the grounds of belief ascriptions and the functions of epistemic modals. In this perspective, relativistic models of modal meaning may have to be enriched with realistic considerations. The reasons for the enrichment have emerged through the reflection on the method and epistemology of science established by Galileo and improved by successive generations of scientist. These reasons have then been documented through arguments presented by Lyons and other scholars of linguistic sciences who sustain that beliefs, modals and discourse analyses should be in consideration of physical propositions, nonverbal patterns, and diagrammatic representations of disciplinary genres. In this framework, beliefs and modal connotations are made dependent on 'possible worlds' references and truth-conditional discourse with consequent definition of *objective* and *alethic* meaning categories.

The arguments posed by the 'realist' group specify the importance of relating modal meaning to 'probability inherent in physical phenomena, verified knowledge, rules and ethics of disciplinary realms. Since the concepts conveyed by each modal particle appear to be discipline and time bound, they can be considered historically and culturally determined. Even though limited in number, and in need of more extensive qualitative and quantitative analyses, the description of modal functions in multimedia texts, attempted in the present study seems to indicate that modal choice and meaning draw on statistical data and on the nature of physical processes. The implication carried out by the modals discussed seem to confirm that researchers evaluate the data through dialectical reasoning and critical judgement. Their propositions are based on interdisciplinary knowledge and research findings which are the main focus of scientific argumentation. Scientists use appropriate modal elements to shift responsibility to the data and other components of the research worlds. As a result, the modals involve the addressees in the reasoning and evaluating activity and open the text to cooperation and reciprocity. The model of analysis suggested would require a

discipline-driven approach in the study of modals and other epistemico-pragmatic structures. This would allow a better framing of the convergent evidence and know how that characterise scientific propositions and multimedia discourse.

In general, the discussions and comments presented in the paper indicate that in scientific context, the physical realities and their mutability appear to have a greater influence on the choice and meaning of modals than the need for a scientist "… to humble himself or herself before the community as a whole" (Myers 1989:4). Toulmin's cautionary words about relativistic interpretation of scientific discourse remind us that although decisions about scientific development may be taken by authoritative scientists:

> …the ultimate verdict on them remains an objective, even a factual matter. For the ways in which Nature will actually respond to our attempts at understanding her is something that goes beyond all tastes, and all human power to alter" (Toulmin 1969:88).

Thus, it seems reasonable to conclude that the complex and multiple fields of knowledge investigated by science and the relative discourse domains may be better understood through 'naïve realistic' lenses. More satisfactory definition of modals in scientific communication may also require heeding Lynch's suggestion that:

> "… to understand what scientists do, what the significance of their conversations are, how their writing should be interpreted and so on, you must become as familiar with their subject matter as the scientists themselves are". (Lynch 1982:147)

In this perspective, researchers interested in analyses and descriptions of the discourse of multimedia genres should, like anthropologists do, immerse themselves into the culture of the disciplinary community and become conversant with its language, conventions and representation models. The ethnolinguistic experience could enhance awareness of how physical properties, experimental results, verbal and non-verbal codes interrelate and determine the choice and meaning of terms, concepts and modals in these domains of discourse. Familiarity with the scientific research worlds would then favour insight into how meaning is not arbitrarily imposed on modal elements. It depends on a dialectico-pragmatic interaction. Therefore, its description must be worked out in light of space/time-related epistemic, pragmatic, intra-textual, inter-textual and disciplinary frames of reference. The gaining of this holistic perspective on text and discourse processing besides allowing better descriptions of modal denotation could favour possible development of more effective pragma-linguistic research and teaching models.

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Book Review

Wissen, Kommunikation und Selbstdarstellung.
Zur Struktur und Charakteristik römischer Fachtexte der frühen Kaiserzeit

Thorsten Fögen

Monographie

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Reviewed by:
Christer Laurén
Professor emeritus (Skandinavistik)
Vasa University, Finland
chl@uwasa.fi

Fachtexte der Antike II

Thorsten Fögen hatte bereits 2005 ein Buch mit ausgewählten Beiträgen von einer Tagung über Fachtexte und Fachsprachen in kulturhistorischer Tradition publiziert. Die vorliegende Monographie „Wissen, Kommunikation und Selbstdarstellung. Zur Struktur und Charakteristik römischer Fachtexte der frühen Kaiserzeit" (2009) ist die überarbeitete Fassung seiner Habilitationsschrift.

Hauptteil A (S. 9 – 105) behandelt die Fachkommunikation mit folgenden Untertiteln: Fachtexte und Fachsprachen, Charakteristika von Fachtexten und Fachsprachen aus der Sicht antiker Autoren: Eine Synopse. Die Transformation griechischer Wissensbestände durch römische Fachschriftsteller.

Hauptteil B (S. 106 – 289) hat die Untertiteln: Vitruv: De Architectura, Columella: De re rustica, Plinius der Ältere: Naturalis historia, Frontin: De Aquaeductu urbis Romae.

Thorsten Fögen ist insbesondere an der Verbindung der antiken Fachliteratur mit der Schönliteratur interessiert. Die Erforschung antiker Fachtexte und Fachsprachen hat innerhalb der klassischen Philologie eine lange Tradition. Selten hat man sich jedoch mit der Literarizität der Fachtexte beschäftigt und so die Möglichkeiten der interdisziplinaren Forschung vernachlässigt. Gleiches könnte man auch von der philologischen Forschung der Skandinavistik sagen, der in diesem Bereich die vielseitige Fachsprachenforschung der Germanistik fehlt. Fachsprache als Objekt der Forschung wird oft nicht geschätzt.

In verschiedenen modernen Sprachwissenschaften sieht man keine Verbindung zwischen linguistischen und literarischen Ansätzen. Einzelne Studien zeigen, dass der Grenzenbereich nicht leicht zu definieren ist.

In der Skandinavistik ist in den 80er Jahren zwar ein Interesse an der Sprachgeschichte zu spüren, das jedoch nicht der Philologie entspricht. Fögen diskutiert die Möglichkeiten der Rhetorik, die eben die Kulturgeschichte beleuchten könnte.

In der Altphilologie ist das Gebiet der Fachsprachenforschung durch die Erforschung der Texte verschiedener Disziplinen und einzelner Autoren vertreten. Ein vergleichender Ansatz gehört zu den Desiderata des Gebietes. Auch fehlen manchmal moderne Ausgaben von antiken Fachtexten. Im Grunde sind die römischen Autoren von Fachtexten nur schwach vertreten und ihre Darstellungsstrategien und Selbstpräsentation wenig ausgeprägt. Die griechischen Autoren dagegen stehen im Vordergrund, auch in der Textlektüre im gymnasialen Griechisch- und Lateinunterricht.

Hauptteil A enthält vieles, was für die Fachsprachenforschung in den lebenden Sprachen von Interesse ist. Havráneks Modell wird mit Recht als zu rigide kritisiert. Bisweilen ist der Leser geneigt, Einwände zu erheben wie (S. 15) bei der Behauptung, dass bei ”hochentwickelten Disziplinen” die Termini (und die Fachsprache) stark konventionalisiert und standardisiert wären. Da die Objekte und damit die Methoden verschiedener Fachsprachen wissenschaftstheoretisch sehr verschiedener Art sein können, sind einige Begriffswelten leichter terminologisierbar, andere hingegen schwieriger in Termini zu fassen. Auch lässt sich das gesamte Gebiet der fachsprachlichen Kommunikation nicht in ein und derselben Weise kategorisieren. Man könnte sie mit dem Begriffsfeld ”Domäne” vergleichen; man braucht diesen Begriff für verschiedene Zwecke und darum kategorisiert man auch verschieden, d.h. es entstehen viele Begriffssysteme.

In den Vorbemerkungen zu seiner Behandlung von Vitruv und dessen Werk De architectura präsentiert Fögen Vitruv als einen Autor der antiken Architektur und Ästhetik. Fögen bezeichnet es als nahezu undenkbar, dass ein Literaturwissenschaftler Vitruv lesen möchte. Vitruvs Werk hat einen Stil, dessen Schwerpunkt auf der Sachdarstellung liegt, und eine Terminologieverwendung, die dem gebildeten Geschmack der meisten literarisch erfahrenen Philologen zuwider wäre. In einer Note (S. 106) wird Eduard Nordens „Die antike Kunstprosa” zitiert: „Vitruv …schreibt auch wie Varro, roh, unbeeinflusst von der modernen Technik …” Norden ist nicht der einzige, der ältere Fachtexte in dieser Weise charakterisiert. Fögen zeigt, dass man mit dem vergleichenden Ansatz weiter kommen kann.

Leider ist über Vitruv außer durch seine eigenen Einführungen in seine Bücher sehr wenig bekannt. Er entwirft dort zum Beispiel ein umfassendes Bildungsprogramm für den Architekten seiner Zeit, der ein Gelehrter mit beachtlicher fachlicher Spannweite sein müsste.

Möglich ist es, dass er ein Ideal zu beschreiben versuchte. Vielleicht sollte man Vitruvs Ideal mit dem Konzept von Cicero (und Quintilian) des orator perfectus vergleichen (S. 113). Beide stellen ihr Fach als nicht nur praktisch orientiert, sondern auch theoretisch fundiert dar; der Architekt ist wie der Orator bei Cicero ein vir bonus (dicendi peritus). Auch der Geograph Strabon hat ähnliche Ambitionen. Fögen behandelt in Hinweisen auch kurz spätere Autoren wie Isidor von Sevilla und andere, die ein ähnliches Bildungsprogramm befürworten. Fögen bemüht sich, sein Verständnis holistisch zu erweitern und Autoren nicht isoliert von Zeit und Kultur zu analysieren.

Columellas De re rustica ist ein umfassendes Traktat über das Agrarwesen. Das Werk hat eine Sonderstellung innerhalb der Literatur über die Landwirtschaft da die Prosadarstellung nämlich mit einem Lehrgedicht verbunden ist. Darum wurde er mit dem Maßstab, der sonst an literarische Gattungen angelegt wird, gemessen. Er wird lieber mit dem rohen Varro als mit Cato verglichen, was nicht berechtigt ist.

Auch im Falle von Columella gibt es über seine eigenen Quellen hinaus sehr wenig Wissen über den Autor. Fögen verwendet und interpretiert dieses Wissen, um Columella vor dem Hintergrund der römischen Landwirtschaft und deren Bedeutung für das Ethos und den mos maiorum zu analysieren. Für die Landwirtschaft ist ja die Quellenlage eine völlig andere als für die Architektur. In der Anthologie, die Fögen publiziert hat, gibt es einen Artikel über den Patrizier Cato und sein elegantes landwirtschaftliches Handbuch, das mit den Ambitionen von Vitruvs und Columellas Büchern verglichen werden kann.

Plinius der Ältere und Frontin werden ebenfalls mit Akribie in vergleichbarer Weise analysiert. Der letztere ist, wie Fögen zeigen kann, unterschätzt worden. Wenn moderne Linguisten Fachtexte untersuchen, haben sie viel zu oft Vorurteile gegenüber der Fachprosa im Allgemeinen. Dies ist auch ein Grund dafür, dass es zu wenige moderne philologische Analysen von heutiger Fachprosa gibt.

„Vitruv, Columella, Plinius und Frontin erheben allesamt den Anspruch, mit ihren Ausarbeitungen etwas bisher nicht Dagewesenes zu präsentieren, das den (zumindest vorläufigen) Gipfelpunkt fachlicher Darstellung für die betreffenden Bereiche bildet." (S. 290)

Thorsten Fögens Monographie über altphilologische Fachtexte gibt den Forschern des Altphilologischen wie des Neuphilologischen ein Werkzeug mit innovativen Ideen und Resultaten an die Hand.

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Contact:

The LSP journal
Copenhagen Business School
Dalgas Have 15
DK-2000 Frederiksberg
Denmark
Email: lsp@cbs.dk