

FLEXIBLE CONCEPT MAPPING

Alfredo Tifi, *ITIS "E. Divini" San Severino Marche (MC, Italy) – WWMAPS*
Antonietta Lombardi, *Direzione Didattica Primo Circolo Novi Ligure (AL, Italy) WWMAPS*
José Domingo Villarroel Villamor, *University of the Basque Country, Spain*
Email: alfredo.tifi@gmail.com, tvillarroel@gmail.com, antonieta.lombardi@gmail.com

Abstract. In this paper we want to analyze some real cases of concept mapping and evaluate the necessity of accepting forms that are non-orthodox, both in the normal language and in a rigorous model of concept mapping syntax, provided that these forms are aimed at facilitating dynamic change of cognition and integration of new knowledge. In other words we believe that if the concept map maker is pushed to create her/his concept map within an excess of constraints, we would be at risk, as educators and mediators, for losing the main opportunity, given by this tool, to know, sustain and evaluate the learning process that is having place. The overload of working memory due to the constraining effect of the so called "rules for good concept mapping", has a very different role for children and for adults, as well as for concept map makers in agglutinative languages, as the Basque one. We want initiate a progressive and aware release of an excess of rigorosity, finalized to a better adaption of mother language to the necessities of concept mapping and vice versa, in every case.

1 Introduction

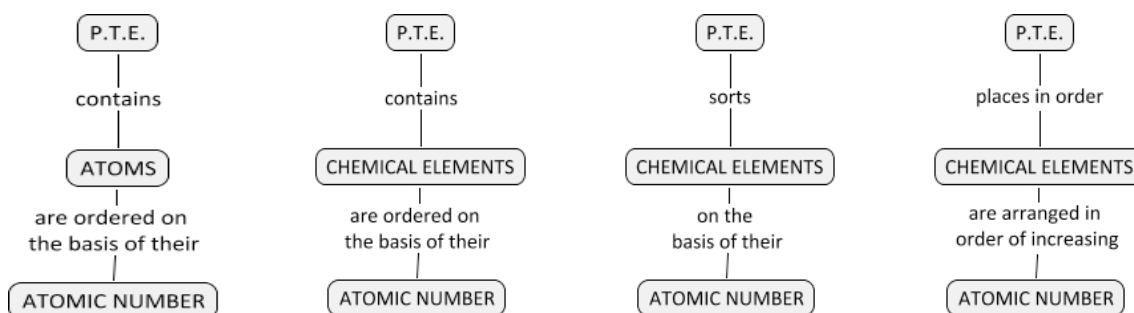
This research is aimed at both: a) explaining the rejection of concept mapping by adults and of some secondary school students as partially due to the highly elemental character of the ternary propositional structure of concept maps, compared to the complexity of relations that are managed by the adults in their natural language, and b) to show how these limits can be (partially) overcome by approaching further the language of concept mapping to the natural language, by enriching the variety of admitted forms for linking phrases and concept labels, by admitting exceptions to some syntax rules of both languages, reducing to the essential minimum the rules that are really mandatory. For example, nouns and pronouns are not advised in linking phrases, and some authors claims for single-word links (Kharatmal & Nagarjuna, 2006). If we want the students to construct accurate and unambiguous propositions, then the rules and conventions that are *not* strictly and explicitly related to Ausubel's background of concept mapping, should be released. For the same theoretical reasons we are convinced that the basic core of concept mapping is the most privileged code to interface with the processes of meaningful learning construction in every field, as described by Ausubel's, therefore it would be an error to interchange among various forms of knowledge representation, maybe downstreaming the specificity of each knowledge domain, if the main task is not the representative, but the metacognitive one, and if we want to give the teacher a proper tool for mediating learning.

2 Analysis of simple - but troubled - cases of concept mapping

Let's start from this example, reported from a chemistry class with fifteen years old students of one of the Authors. The following sentence was read in class from Italian Wikipedia and translated here:

"The periodic table of elements is the key by which atoms are ordered on the basis of their atomic number Z. Conceived by chemical Russian Dimitrij Mendeleev in 1869, the PTE..."

The first three subsequent versions of the initial part of the C-map show how the plain text was decoded, recoded in a Cmap and restructured by the students that were at the very beginning practice of concept mapping.



| | | | |
|--|--|--|---|
| <p>In this first step three concepts were elicited from the text and were properly ranked. This step combines the major efforts in decoding and recoding in concept mapping.</p> | <p>An error, from the original text, leaped out and was corrected in #2.</p> | <p>The teacher focused upon the first proposition in #2 and suggested that a better verb than "contains" had to be found, because those elements aren't "thrown in" randomly in the PTE.</p> | <p>This change would restore independence between the two propositions. But the first independent proposition don't answer to the question "which kind of order?", whereas the second doesn't tell "where".</p> |
|--|--|--|---|

Fig. 1. Three stages in the construction of the first C-map for 15 years old learners, and a try to create two independent ternary propositions.

The passage from plain text to #1-2 implies the recognition of concepts, of their role and rank in the first sentence of the c-map. Passing From #2 to #3, the first proposition has gained more precision, but the students avoided the repeated reference to the ordering in the second proposition. As a matter of fact, the first linking phrase, "sorts", has a conceptual meaning that get complete with a sorting parameter, i.e. the concept in the second proposition. So #3 is viewed as a single coherent proposition by the students, formed by three concepts and two linking phrases (quinary). This isn't orthodox as a form in concept mapping. In fact, if we read the second proposition in #3, [Chemical Elements on the basis of their Atomic Number], we admit that it doesn't make sense for its incompleteness. If we further add a verb in the second link (as in #4) we could gain independence for the second phrase. But looking at #4, we introduce an element of ambiguity: there is not an explicit way, for the inexpert reader, to infer that the "elements are ordered..." inside the periodic table, and not elsewhere. The extended proposition in #3 hasn't this drawback.

We ask ourselves to what extent and for what end should we further rearrange this map to gain both explicative capability and strict ternary structure and independence of every proposition.

We maintain that #3 is a good compromise between orthodoxy and meta-cognitive restructuring of knowledge. So #4 doesn't add nothing to the cognitive work of the student, but it just would defer to an a priori tie of rigid rules commanded by orthodox concept mapping.

Moreover we cannot ascribe the difficulty in reproducing the correct meaning in the C-map to an intrinsic complexity of the original text. The example phrases is ubiquitous in normal texts, and we cannot renounce to the advantages of concept mapping due to a few cases like this one. Rather than evaluate formal observance of the rules in the finished C-map, we should appreciate what a work of conceptual re-modelling and refining takes place *during the process* of concept mapping.

Finally, let's image what a psychological impact would we have if we would say: "no, it doesn't work because the second proposition has not a complete meaning", addressing to the student that elaborated #3 C-map.

We should remember that the "living entity" we must respect, help and encourage to grow, is the cognition of that student, not the representation of it.

Let's examine the next example showing a typical situation, where the full meaning within a knowledge domain, results from a larger scale of the "atomic" propositions, that is from the "relations among relations".

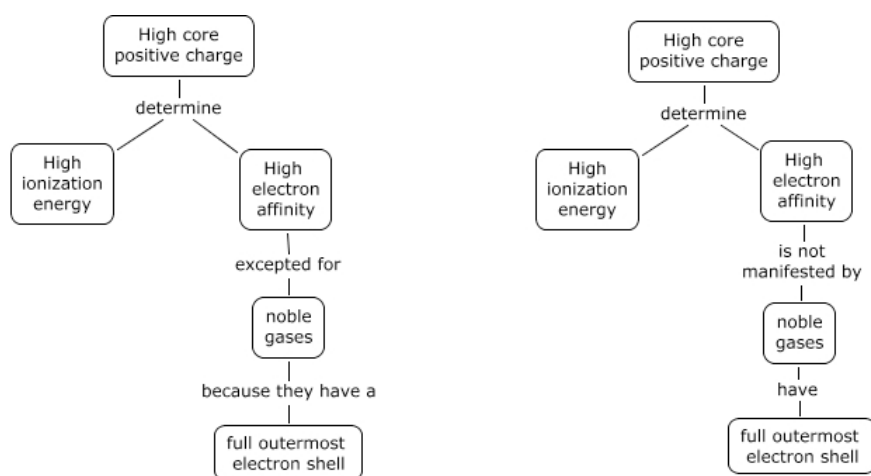


Fig. 2: the left c-map is the original one. The right one has been modified for the purpose of this paper to show the consequences of rendering all the propositions independent.

The following two propositions could be written as independent claims, but renouncing to the completeness of correlated meaning:

1. [High electron affinity] is not manifested by [Noble gases]
2. [Noble gases] have [full outermost electron shell]

A complete sense of the correlation is displayed by the complete –original- sentence:

[High core positive charge] determine [high electron affinity] excepted for [noble gases] because they have a [full outermost electron shell]

The sentence is of a “chain text” type; nevertheless it has a well distinct conceptual structure.

It is worth to notice that this sentence was not based on a text source, but on the knowledge of the student, under the synchronous reviewing - mediation of the teacher, who reminded him that a high core-charge doesn't always correspond to a high electron affinity.

If a c-map is the result of a mediation process, it is always a good one. Furthermore, The dynamic – explicative character of the C-map is given by the use of meaningful linking words as “*excepted for*” and the explanatory “*because*”. If we renounce to these words for the purpose of adhering to an abstract rigorousness, we get a c-map whose real meaning need to be inferred by an expert reader. On the contrary, we believe that a C-map that aims at being a representational resource, should respect the priority of reducing the extent of implicit content for a generic reader. This can be obtained by resorting to articulated linking phrases and composed concept labels, as we can see in the next section dedicated to Euskara language.

We can see that often in the language *the relation* between two concepts *is related* to a third concept. This relation is not of a binary type and we won't renounce to make a C-map of a certain subject only because it contains some such "Y" type of relation.

Let's see an example of this case, arisen while mapping the following text in a collaborative reading of a book (Le Couter & Burreson, 2004, pag. 234), among seventeen years old teamed students:

"Combined with morphine , scopolamine is used as the anesthetic known as "Twilight sleep..."

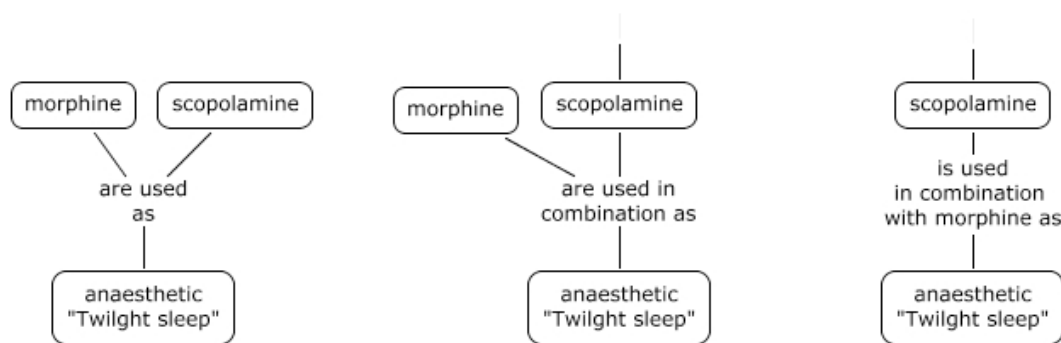


Fig. 3. How to solve a “Y” relation by “embedding” a secondary concept in the linking phrase.

The first arrangement assigns the same logical role to the concepts of [scopolamine] and [morphine]. But that solution was modified because it gave the false belief that each substance could be used separately as an anaesthetic. So the linking phrase “are used as” was properly changed by the students to give the second arrangement. However the C-map concerned hallucinatory alkaloids, so that scopolamine was the in-context concept, whereas morphine, being a drug, had an ancillary role, as pointed out by the “dead side entry”, to the left of the "main stream" in the middle C-map. In these cases we propose that an exception to the rule that prohibits the use of concepts in the linking phrase could be tolerated, as in the third arrangement in Fig. 3.

A different occurrence of concepts added in linking phrases arises often when we need a classificatory word (a “is a” kind of word) to characterize (and disambiguate) a concept. Examples drawn from students and from various c-maps from the 2nd CMC proceedings, are the followings.

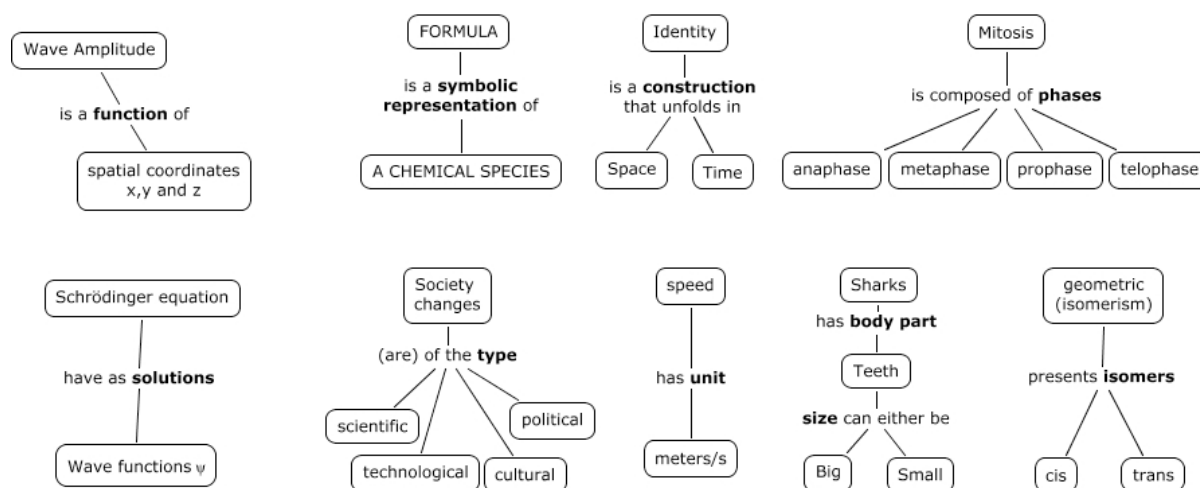


Fig. 4 Bold words in linking phrases are category terms, i.e. very general concepts that are out of context. (these excerpts were adapted from students' C-maps and from the 2nd CMC proceedings: Vol 1, pp. 213, 426, 500, 557, 3; Vol 2, pp. 72)

It is manifest that those words, as *construction*, *phase*, *solution*, *type* etc., have a role as categories and not as relevant concepts in the domain of these C-maps. Sometimes these *category nouns* are used also as root or first level concepts in the same C-map, as in the case of isomers, in the last fragment of a C-map about chemical isomers. So these nouns can be properly admitted in linking phrases, permitting also a considerable help in the construction of linking phrases in Basque language.

Another degree of freedom is due to the use of simple conjunctions and prepositions, without verbs (e.g.. *with*, *either*, *or*, *through*, *such as*, *by*, *from*, etc.), while one of the (non-written) advices in concept mapping training, claims that a linking phrases should always be a *verbal* predicate, as: *includes*, *can be*, *have*, etc. Frequently these linking word have a [verb] that remains understood, as in: *[are] either – or*; *[are associated] with*; *[are made] through*; etc. Or maybe the verbal predicate is part of the first concept – event, so that the linking phrase serves only to complete the proposition. But conjunctions, prepositions or articles, serve sometimes to separate two parts of the same concept, as in Fig. 5 (from 2nd CMC Proceedings, pag. 238 vol.I).

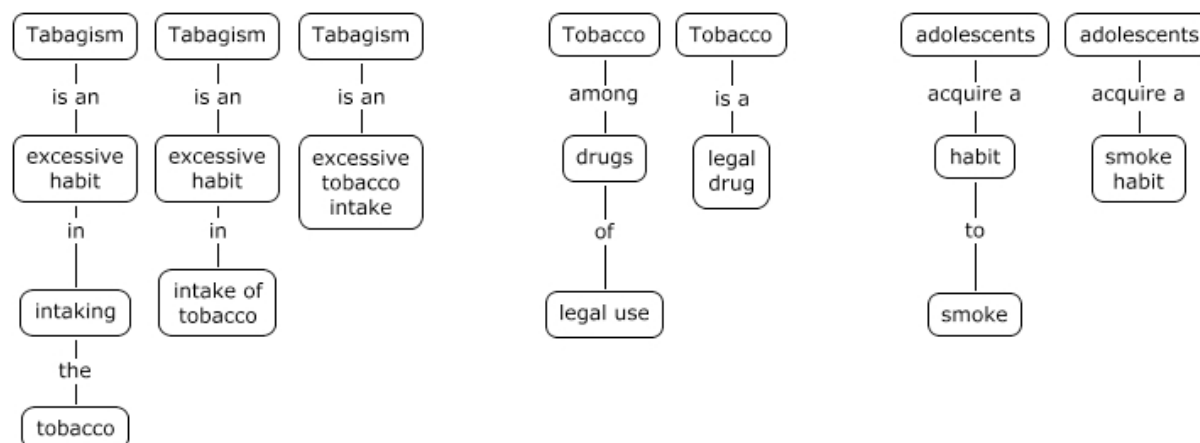


Fig. 5 Concepts that were divided by linking word has been recomposed in each of three fragments of the same C-map of a 13 years old student. The original sequence is the first on the left of each group. The middle one has an implicit verb "are" that accompanies the preposition "among", but the lower "of" in the same chain has only the role of separating two parts of the same concept.

This kind of concept mapping often indicates a poor metacognition or a verbatim concatenation of words from textual sequences. In other words, the capability to group words to generate articulated concept labels, relies on the recognition of the logic role of each term, therefore this grouping is a key factor in meaningful learning. Furthermore, if grouping requires more than putting words together, i.e. substitution with single terms having the same meaning (e.g. "drugs of legal use" = "legal drugs"), it is required also a lexical experience to the learner.

This grouping of concepts can be a very serious issue when it is asked by the excessive complexity of a text or of a thought. As an example let's take these two statements (Le Couter & Burreson, 2004, pagg. 247, 239):

“Tobacco changed the role of opium in Chinese society, from a medicinal herb (that was swallowed as pellets or drunk as infusion) to an addictive forbidden drug to be smoked”;

“This level of poverty would have saved (such) a (elderly herbalist healer) woman from ergotism (because of being unable to purchase contaminated flour) but ironically, as maybe the only person untouched by the ergot poisons, she became even more vulnerable to the accusation of witchcraft”.

The first complex statement (left part in Fig. 6) requires the adoption of *flexible strategies* of reconstruction as *a*) articulated concepts, *b*) quinary propositions and *c*) implicit verbs (to avoid the repetition of the verb “changed” three times). The second one (right part in Fig. 6) requires an harder work of restructuring and choice of composed concepts, the elicitation of an implicit causal effect (of immunity as due to magical arts) sustained by the *flexible* grouping of concept labels and the ungrouping (through the preposition “of”) of the single concept of [accusation of witchcraft] that was split to give the word-concept of [witchcraft] and the slanting link.

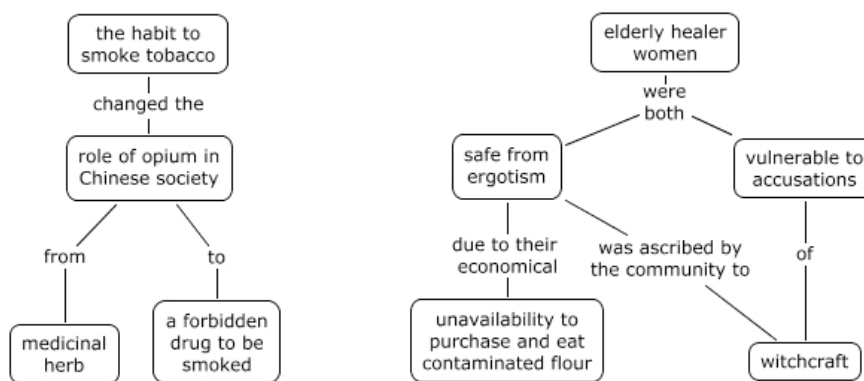


Fig. 6 Fragment of concept maps of very complicated texts. The concepts are “constructed” in such a way to highlight the smallest number of fundamental relations, avoiding to “atomize” concept labels.

We maintain that such rearrangements (that have taken several attempts in changing the rank and the organization of the concepts and of the C-map) could demonstrate a metacognitive insight of the learner, although these fragments of C-maps are not very good instances of orthodox forms.

There is a sharp difference between the excessive grouping or - on the opposite side - “atomizing” of concept and linking phrase labels, whether these actions result from the lack of restructuring of the plain text and of the “thinking stream”, or when they derive from an intrinsic complexity of the knowledge domain. Complexity is characterized by the presence of several “scales of observation” or levels and it is a hard and valuable job for the learner to choose the most proper ones when “circling” concept labels in closed shapes, if she/he wants to map both the details and the main ideas of her/his complex natural language.

The last example was spurred to us from a different concern (application of logics in concept maps) by M. Kharatmal (personal communication). It illustrates how - even in simple statements - we are compelled to use articulated linking phrases. This seemingly clear statement: *“Plastids are found in plant cells only”* could be easily transformed in a concept map proposition if we could consider [Plastids] as the more inclusive concept, as in the first proposition Fig. 7 (even in that case the linking phrase must be articulated because of the logic role of “only”).

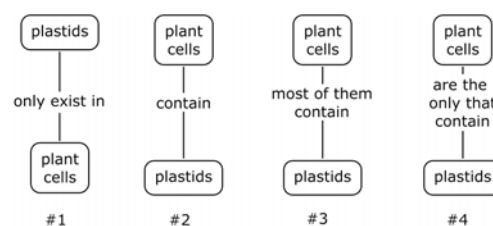


Fig. 7 A problem of logic in a (apparently) simple statement. If the concept of plant cell has to be used as being the most inclusive, there is an intrinsic irreversibility of the logical meaning of the term “only” that prevents us to shorten the linking phrase in #4.

But, as it would be very likely in a C-map about plants, the issue becomes more complicated if the [plant cell] concept claims to be the more inclusive one. We must notice that the C-map fragment should make explicit *only* the information that is contained in the statement, nothing less and, above all, nothing more that could be already part of our knowledge, as the awareness that root cells in a plant haven't plastids, as an example. In this case the claim about plastids informs us that these objects are findable *only* in cell plants, whereas it don't say whether *all* the plant cells contain plastids or not. So the proposition in the C-map should express for sure that if a cell contains a plastid, that cell must to be a plant cell. Instead the #2 proposition gives us extra (and untrue) information that *all* plant cells have plastids, while the #3 gives the (true) *extra* information that there are plant cells without plastids. Finally, #4 logically revert the original statement with its articulated (and non-orthodox) linking phrase. We are free to use *plastids* or *plant cells* as the subject in natural languages sentences, and generally our choice is the one that transmits the most correct meaning in the simplest form. Generally speaking, in concept maps, right inclusive relations are determined by the context, and the awareness of the rank between concepts in each couple is a point of force of concept mapping, but it constitutes also a binding constraint to our expressive capability. That is to say that concept maps are not a "natural" language, and often we can only approximate the complexity of the text elements - parts that we have decided to restructure as a C-map. The quality of the approximation, in such cases, depends strongly by the use of flexible criteria.

3 Concept mapping in Euskara

The Basque language, (native: Euskara) is an *agglutinative* language, i.e. most words are formed by joining morphemes together. Moreover, Euskara is a Subject-Object-Verb (SOV) type language (de Rijk, 1969). As an example, the sentence "The Water is in the Sea" is written: *Ura (water) itsasoan (in the Sea) aurkitzen (found in) da (is)*. Evidently the structure of Basque language is very far from the [subject]—verbal predicate + preposition → [object] form of analytical languages, as the English or the concept maps ones, and this difference generates problems that can be solved through a flexible - generalized use of propositional structure and through some slight license in the grammar.

3.1 Construction of propositions

There are two ways to solve this problem. The first one (Fig. 8a) is not to observe the grammatical order asked by Basque sentences; we do not think that it could be a right solution because it would decrease communicative effectiveness. In the second solution, we can divide the sentence into two parts and link them by special words like "zera", "ondoko" or "honako" (They can translate in English in this way: "the following one:" or "this one:"). This is somewhat equivalent to the addition of pronouns or category nouns in English linking phrases.

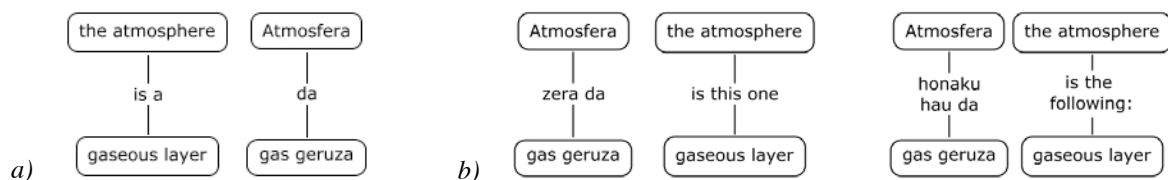


Fig. 8 a) Unacceptable proposition obtained by verbatim translation; b) Two alternative solutions obtained with pronouns.

The insertion of a pronoun in articulated linking phrases helps also in those cases of nouns that are modified by a suffix that is requested by the verbal predicate, as can be a preposition. If a Basque object noun has such a suffix, it becomes unsuitable as a subject of a derived proposition (Fig. 9a). On the contrary, the prepositions are part of verbal predicates in English, where nouns remain unchanged and usable for other propositions. If the subordinated concept is preceded by a pronoun in the linking phrase, we make only a tiny error in Basque grammar by leaving off the *-n* suffix (Fig. 9b).



Fig. 9 a) Incorrect derived proposition caused by *-n* (in) suffix. b) *honako* pronoun dispenses us from using the *-n* suffix in the noun. Notice that "naked" nouns (as *itsaso* = sea) are never used in Basque, because the articles (*-a, -ak*.) are always merged with the nouns.

3.2 Use of prefixes

The second problem is that in Basque language are needed suffixes, for example “-k”, to mark the subject of a transitive predicate. Let's take into consideration the following two sentences: “The atmosphere is a gaseous layer” (and) “The atmosphere has water”. In Basque these sentences can be translated as “Atmosfera gas geruza da” (eta) “atmosfera**rak** ura du”. How to build up concept maps if the same concept changes from *Atmosfera* to *Atmosfera**rak*** in the two branches? Here (Fig. 10) is our solution.

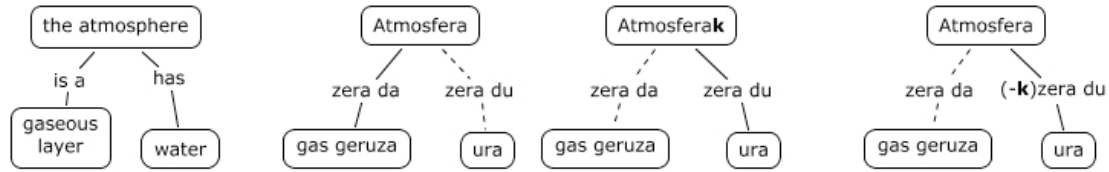


Fig. 10 The dashed lines indicate incorrect sentences. The solution is to move the transitive prefix (-k) from the subject to the linking phrase.

A rich collection of math and science c-maps in Basque language can be accessed from the University of the Basque Country Folder in IHMC Public Cmaps (3) server (web shortcut in references).

4 Generalized rules for “easy” concept mapping

Concept mapping is never an easy task for a learner of a new subject. But there are nevertheless some simplifications that should be allowed to concentrate the efforts upon the metacognitive task.

4.1 Construction of concepts

Once that the Focus Question has been identified (this doesn't mean that the focus cannot be changed later on), the first task is the *construction of concepts*. The term “construction” implies that concepts aren't somewhere in texts or in our mind, but that - in every not-elemental knowledge domain - they have to be chosen, assembled from words and (if possible) transformed with nominalization actions (Guastavigna 2004). These *nominalization* operations (reducing a group of words to a single term) are not always possible for the learner, whereas the individuation of evocable and aware units of experience in the structure of her/his cognition–affection, constitutes a priority for meaningful learning. Therefore we allow concept labels to be formed by an *indefinite number of words*. In our experience we don't say to our students: “there are too many words in that node”, but: “if you re-read those words, are you sure that you are still viewing them as a single concept, and that they cannot be divided in two or more related units?” This question hasn't always an absolute answer. In very complex knowledge domains there are margins of subjectivity and may be favorable to subdivide the fundamental relations in a few well-articulated concepts, in such a way to highlight a few fundamental relations (Fig. 6), rather than “atomize” the network as made of single-word concept labels.

We can realize that the real criteria for good “concept designing” is indeed a criterion of individuation of the minimum number of the most fundamental relations and of placing them in a central position of the structure.

4.2 Flexible construction of propositions

As we have seen in 2.1, concepts can be constructed, or individuated, only having an idea of their involvement in the reciprocal relationships. It means that even the inclusivity relation is determined by the initial choice of the most fundamental relationships in the knowledge domain. The asymmetry of the inclusion between two concepts is not negotiated here, as being a basic component of metacognition. But it should be remembered that this inclusion relation has to be interpreted as a “local” type (it doesn't imply a hierarchical or pyramidal C-map on larger scale) and *relative* to the context, determined by the focus question and by the root concept, as Joseph Novak has pointed out (Novak & Gowin, 1984). On the other hand, an important element of flexibility is that “*propositions contain two or more concepts connected using linking words or phrases to form a meaningful statement*” (Novak & Cañas 2008). As we have seen in several examples of the second paragraph, the construction of quinary propositions (formed by three concepts and two linking phrases) is not always a symptom of insufficient restructuring of the C-map by the learner. Therefore we accept generalized and extended propositions, provided these can be perceived as “*units of meaning*” (Novak & Cañas 2008). In the

main C-map of the latter reference we can see some propositions with non verbal linking phrases that we have classified of the type with *implicit* verb, as in:

[Perceived Regularity or Patterns] — in → [Events (Happenings)], [Objects (Things)]

[Interrelationships] — between → [different Map Segments] (this one could be merged in a single concept)

[Organized Knowledge] — necessary for → [Effective Teaching], [Effective Learning] (verb “is”, implicit)

As there are extended (quinary) propositions, as the followings:

[Concepts], [Propositions] — are → [Hierarchically Structured] —in→ [Cognitive Structure]

[Concepts], [Propositions] — are → [Hierarchically Structured] —especially with→ [Experts]

[Concepts] —are→ [Labeled] — with → [Symbols], [Words].

In the latter statement the Authors presumably wanted to highlight the role of *Labeling* as an event-concept, rather than to use the simpler form [Concepts]—are labeled with →[Symbols], [Words], this being another form of flexibility in proposition construction.

We want to remember again that all forms of grouping, of using nouns in linking phrases, are very advantageous in agglutinative languages as in the Basque one.

5 Summary

We have reflected enough on the relations between mother-tongue language and concept mapping as a pedagogical language, to draw the following conclusions. Language and its logic develop as the cognitions of individuals develop. For the younger, children at primary school, the oral or written language has a strict resemblance with the propositional – simple – structure of concept maps (minimal phrases, single word labels for concepts and linking phrases). In that developmental age, as we and many other educators have verified, the systematic use of concept maps (making, reading as narrations) has, among other advantages, the potentiality to help the growth and refinement of language. But with the older and the adult learners, the most part of whom haven't got trained with concept maps, the written and oral language, as their cognitive performance, have been developed along independent ways. In this case the impact of concept mapping, forced with the same elementary criteria, if restrictively applied, can represent a sort of overloading constraint that can discourage older students and adults and keep them far from concept maps. To fill the gap between the natural language and the concept mapping language in adults, and to engage them in concept mapping, a wider acceptance of conventionality and subjectivity in their elaborations as learners is required, provided that some basic criteria – the ones that are correlated to metacognitive activity - are respected. We also need a more flexible managing of the basic criteria of concept mapping, to fit complex and sophisticated knowledge claims that arise in the natural language, provided that main relations and conceptual nodes are well defined-chosen anyway in the c-maps.

It is worth noting, agreeing with one of our reviewers, that certain settings, e.g. a teacher generated concept maps used for instruction, might call for more formalized concept mapping techniques to allow for a greater precision and rigor of expression, and also for a model of well made structured concept maps to imitate.

References

- Kharatmal & Nagarjuna (2006). A Proposal To Refine Concept Mapping For Effective Science Learning, in A. J. Cañas & J. D. Novak (Eds.), *Concept Maps: Theory, Methodology, Technology. Proceedings of the Second Int. Conf. on Concept Mapping*. San José, Costa Rica: Univ. de Costa Rica.
- Le Couter P. & Burreson J., *Napoleon's Buttons, 17 Molecules that Changed History*. Penguin Editor, 2004.
- de Rijk, R. (1969). "Is Basque an SOV language?" in *Fontes Linguae Vasconum 1*, pp. 319-351
- M. Gineprini & M. Guastavigna, "Mappe per Capire, Capire per Mappe", Carocci Faber Ed., 2004, Roma.
- Novak, J. D., & Gowin, D. B. (1984). *Learning How to Learn*. New York: Cambridge University Press.
- J. D. Novak & A. J. Cañas (2008). *The Theory Underlying Concept Maps and How to Construct Them*, Technical Report IHMC CmapTools 2006-01 Rev 01-2008. Retrieved April 2, 2008, from <http://cmap.ihmc.us/Publications/ResearchPapers/TheoryCmaps/TheoryUnderlyingConceptMaps.htm>
- University of The Basque Country Cmaps folder, in IHMC Public Cmaps (3) CmapServer: http://cmapsconverted.ihmc.us/servlet/SBReadResourceServlet?fid=1176473710812_276161768_18455