SUPERIORITY OF INDIRECT METHODS IN THE ELICITATION OF KNOWLEDGE OVER DIRECT ONES

MARÍA JESÚS SÁNCHEZ
ALFREDO FERNÁNDEZ-SÁNCHEZ
UNIVERSIDAD DE SALAMANCA

Abstract. The aim of this research is to check whether indirect methods for dealing with the elicitation of knowledge are superior to direct ones in the domain of English as a foreign language. In this case subjects were asked about the core term in nine different lexical fields. This task was done with two questionnaires (direct elicitation technique) and with relatedness ratings (indirect elicitation technique) submitted to the Pathfinder algorithm. Results show the superiority of indirect methods over direct ones and the necessity of considering information empirically obtained. This knowledge allows us to reject our erroneous beliefs and also to ascertain which core vocabulary our students should master.

Keywords: *Indirect method, Direct method, Core vocabulary, EFL, Semantic network, Questionnaire, Relatedness ratings, Pathfinder algorithm*.

1. Introduction

Many knowledge elicitation techniques have been used to obtain the information experts know. One of these techniques involves directly obtaining information by questioning them on what they have learned and how they do a certain task. This is often hard when tasks frequently performed become automatic (Burge 2008). Automaticism is precisely the biggest difficulty that a knowledge engineer has to face when trying to extract knowledge from an expert (Bajo and Cañas 1994) together with the huge amount of information that can be obtained and therefore the difficulty involved in interpreting the data (Márquez Sánchez and Muñoz Cáceres 1994). Villachica et al. (2001) also mention another potencially related problem that can arise when dealing with the inability of experts to state what they know; many experts cannot state knowledge they have learned implicitly, since this is a non-conscious learning (Richards, Schmidt, Kendricks and Kim 2002). For these reasons most of the times indirect methods are used to obtain information (Bajo and Cañas 1994; Cañas *et al*. 1998; Cooke 1994; Gammack and Young 1985; Lin 1997; Meara 2007; Vives Boix and Meara 1994). They are considered indirect methods because experts are not asked to comment directly on domain facts or rules, instead the information is inferred through their judgements of conceptual relatedness. They have the advantage of not involving direct reporting of verbalizeable knowledge (e.g. interviews, questionnaires, etc.) They rely less on verbal behaviour and instead involve inferences about knowledge based on the expert behaviour (Cooke 1994). One way to avoid problems associated with expert self-reporting can be to use cognitive task analysis methods (Villachica *et al*. 2001). Examples include Hierarchical clustering, Multidimensional scaling and the Pathfinder procedure. This one is going to be used in this research because of its psychological validity (Cooke 1992; Cooke *et al*. 1986; Goldsmith *et al*. 1991; Gonzalvo, Cañas and Bajo 1994; Pitarque and Ruiz 1997).

This said, in this study we propose to examine the following research question: the superiority of indirect methods in the elicitation of knowledge over direct ones. This idea

Revista Electrónica de Lingüística Aplicada (ISSN 1885-9089)
2010, Número 9, páginas 97-121
Recibido: 30/03/2010
Aceptación comunicada: 12/11/2010

agrees with research done to improve user interface design (McDonald, Dayton, and McDonald 1988), guide the development of teaching and training programs (Lin 1997; Rowe, Cooke, Hall, and Halgren 1996), and understand expert-novice differences (Cooke and Schvaneveldt 1988; Housner, Gomez, and Griffey 1993; Meara 2007; Schvaneveldt *et al*. 1985; Vives Boix and Meara 1994). This study is valuable since there is no explicit research comparing these kinds of methods in tasks related to foreign languages; at the same time this research helps support previous research dealing with elicitation techniques. Having in mind these theoretical ideas we will compare the effectiveness of two knowledge elicitation techniques, one direct and one indirect, in the domain of English language. It will provide an accurate knowledge of how well the different techniques behave.

Studies (Bitter-Rijpkema *et al*. 2005) indicate that differences exist between experts and novices regarding their methods of work and reasoning. This is why we will elicit knowledge from English native speakers (experts) and from students of English as a foreign language. Subjects will be directly asked to identify the core (nucleus, term around which others are grouped) in different groups of words connected to the same idea (lexical or semantic fields; Richards *et al.* 2002). For the indirect elicitation technique relatedness ratings between concepts will be used. As Beissner, Jonassen and Yacci (1993: 37) state "this method identifies a group of related concepts, asking the respondent to rate the degree of similarity or dissimilarity between each of the pairs of concepts." This structural knowledge provides a network with the pattern of relationships among concepts in memory which depicts the cognitive structure. With this visual aid (network), and considering the number of direct links departing from each node, the central node in each lexical group can be inferred. The one with the highest number of links must be considered the main term, the nucleus. In all likelihood, and in accordance with literature in the field (Bajo and Cañas 1994; Burge 2008; Cañas *et al.* 1998; Cooke 1994; Gammack and Young 1985; Villachica *et al*. 2001), we predict there will be an advantage of the indirect over the direct method with probably relevant consequences for vocabulary teaching.

2. Methodology

2.1. Materials

Lexical material consisting of nine different lexical groups was used. This material was collected having the necessities of students in the first year of English Language majoring in English at the Universidad de Salamanca in mind. It covers morphologically relevant groups with three main categories: nouns, verbs and adjectives (see Sánchez, González and Escobar 2003). It gives information on the selection mechanisms for the lexical fields). Frequency, synonyms and antonyms were considered whenever they were available. Sánchez, González and Escobar (2003) named each semantic group according to our general knowledge as linguists and teachers of English as a foreign language. What comes next is a brief description of every lexical group and the name we decided to assign to each group (in parenthesis) in accordance with our knowledge of the relationships of the terms and of the lexical fields under consideration:

Nouns

1. Concrete nouns related to weather terms (*weather*)
2. Abstract nouns related to honour words (*honour*)
3. Nouns related to sadness terms (*sadness*)

Verbs

1. Static verbs related to the verb look (*to look*)
2. Movement verbs with body displacement (*to walk*)
3. Action verbs (*action verbs*)

Adjectives

1. Adjectives with different degrees of temperature (*temperature*)
2. Abstract adjectives which indicate worriedness (*worriedness*)
3. Abstract adjectives related to physical condition (*physical condition*)

This material has the advantage of having been done with the help of expert subjects, that is, English native speakers. In order to know which terms were more familiar to them, students (N=13) enrolled in Cursos Internacionales at the Universidad de Salamanca, completed the rating of the terms included in every semantic field. English native speakers were asked to judge their familiarity from 1 to 5 (1 meant no familiarity at all and 5 the maximum one). They were also instructed to add some other relevant words related to every lexical group. Several dictionaries were also used to make up these lexical groups (*Longman Language Activator: The World's First Production Dictionary* 1993; *The New Shorter Oxford English Dictionary* 1993) and other resources: the *WordNet* (http://www.cogsci.princeton.edu/cgi-bin/webwn1.7.1, which is a data base inspired by current psycholinguistic theories of human lexical memory), the *MRC Psycholinguistic Database* (http://www.psy.uwa.edu.au/mrcdatabase/mrc2.html) and the *Computational Memory Lab* (http://fechner.ccs.brandeis.edu/wordpools/kfpool.txt). The result is the creation of nine semantic fields ordered according to the criterium of familiarity (see the table below). This material was used in this research:

- In two *questionnaires* to get the term which could designate every semantic field (nucleus).
- Also to get the semantic network for every lexical group with *similarity ratings*. Using this visual aid (network) we could decide which term was the nucleus in every semantic field considering the number of direct links departing from the nodes.

Weather	**Honour**	**Sadness**	**Temperature**	**Worriedness**	**P. Condition**	**To look**	**To walk**	**A. Verbs**
cloud	*faith*	*anxiety*	*boiling*	*afraid*	*energetic*	*to look*	*to walk*	*to close*
drizzle	*honesty*	*depression*	*burning*	*annoyed*	*exhausted*	*to see*	to stamp	*to open*
fog	*Hono(u)r*	*happiness*	*cold*	*bothered*	*sleepy*	*to stare*	to trip	*to stretch*
heat wave	*irresponsibility*	*hurt*	*cool*	*disturbed*	*tired*	*to watch*	to step	*to suck*
hurricane	*truth*	*pain*	*chilly*	*easygoing*	active	to browse	to stroll	*to swallow*
lightning	integrity	*peace*	*freezing*	*obsessed*	beat	to glance	to stalk	*to turn*
precipitatio	morality	*pleasure*	*hot*	*preoccupied*	drowsy	to glare	to stride	to beat
rainfall	sincerity	*relief*	*icy*	*stressed*	relaxed	to gaze	to tiptoe	to clap
storm	trustfulness	*satisfaction*	*warm*	*upset*	rested	to spy	to parade	to kick
sunshine	confidence	blessing	crisp	*worried*	awake	to squint	to strut	to move
thunder	corruptness	delight	mild	anxious	burned out	to glimpse	to march	to slap
wind	deception	joy	frosty	concerned	lively	to peek	to pace	to wave
breeze	straightforwardness	mourning	baking	peaceful	refreshed	to skim	to prance	to wink
shower	suspicion	sadness	scalding	relaxed	drained	to frown	to shuffle	to yawn

Weather	Honour	Sadness	Temperature	Worriedness	P. Condition	To look	To walk	A. Verbs
sleet	deceit	torture	scorching	appalled	fatigued	to scan	to stagger	to lick
snowflake	mistrust	contentment	sizzling	apprehensive	spent	to spot	to sway	to pound
downpour	righteousness	disappointment	frigid	tense	strenuous	to peep	to swagger	to punch
hailstorm	reputation	grief	lukewarm	unconcerned	weary	to lower (eyes)	to flounder	to shake
mist	crookedness	suffering	blistering	carefree	worn	to peer	to keel (over)	to shiver
raindrop	fraudulence	trauma	nippy	joyful	brisk	to scowl	to reel	to tap

Table 1: Lexical Material. Ordered from highest to lowest score in the familiarity index (N=13)[1]

2.2. Questionnaires

The two questionnaires consisted of the 20 first terms in the list above with the highest degree of familiarity (Sánchez, González and Escobar 2003). Lists arranged in different orders (counterbalanced) were presented to subjects so as not to prejudice the task due to the order of presentation of the material. Subjects were asked to decide which term could be used, in every semantic field, to designate the whole semantic field. In questionnaire number 1 participants were given the option of using one member of the group or another term or expression they considered was the name that could encompass all the terms shown in each lexical field (Appendix A). As this would bring a lot of new words and expressions and could be difficult for a posterior interpretation of data, we administered a second questionnaire with the same task and with slightly different instructions. In questionnaire 2, again using counterbalanced lists, subjects were instructed to use one of the terms included in every group of words to designate the lexical groups (see Appendix B). In this way we could compare the data for the 2 questionnaires with different instructions and shed light on this research field.

It was expected that different degrees of expertise could be detected in their choices and in the change in cognitive organization, since learning entails the incorporation of new knowledge to that which we already have (Cañas *et al*. 1998; Gonzalvo *et al*., 1994; Johnson, Goldsmith and Teague 1995). For these reasons both questionnaires were completed by three different groups of subjects. One group was the English native speakers (experts), different group and participants from the ones who rated the terms in every semantic field, and the other two were students with different levels of proficiency in the English language: Intermediate and advanced students. The expert groups consisted of 8 (first questionnaire) and 17 (second questionnaire) American students who were studying Spanish Language and Literature at the Universidad de Salamanca. They volunteered to participate in this research. The other two groups of subjects were composed by students in their first (intermediate level) and fourth year (advanced level) at the Universidad de Salamanca majoring in English Language and Literature. These students also volunteered to participate in this research. The number of subjects in the first year was 20 (first questionnaire) and 13 (second questionnaire), and in the fourth year 21 and 16 (first and second questionnaire).

[1] The terms in every lexical field in italics have got the same maximum score. We only give the first 20 terms in every lexical field, for a complete list see Sánchez, González and Escobar (2003).

2.3. Similarity ratings

Once the terms to be included in every semantic field were selected the next step was to obtain the different semantic networks. In this case we decided to work with subjects who were very far from each other in their level of proficiency: native-speaking experts and intermediate students. In this way it was thought that we could capture bigger differences in their cognitive nets (Gonzalvo *et al*. 1994; Johnson *et al*. 1995; Cañas *et al.* 1998). Expert subjects (N=30), a group of American students enrolled at the Universidad de Salamanca who also volunteered to participate, were presented the first 20 terms in every semantic field (that is, the most familiar) and were asked to judge the relationship between every pair of terms which appeared on the computer screen from 1 to 9 with higher numbers representing greater relatedness. 1 meant that there was no relationship between the terms and 9 meant the maximum relationship. They judged the relationship between all posible pairs with the 20 terms selected (190 pairs), and it had a mean length of 20 minutes for each semantic field. The reason for not having more than 20 terms was to prevent boredom and tiredness in the subjects, factors which are really pernicious for any research (Goldsmith *et al.* 1991). The ratings were submitted to the Pathfinder algorithm (see Appendix C for a full explanation. For technical details of the Pathfinder algorithm see Schvaneveldt, 1990; Schvaneveldt, Durso and Dearholt, 1989; Schvaneveldt et al., 1985) and were analyzed with the parameters $q=n-1$ (n=number of terms in each semantic field) and r (defines the metric used to compute the distance of paths)=infinite. These parameters are used to generate empirically the least dense semantic networks for the cognitive organization of these terms and thus perceive more clearly the relationships among the concepts. Once we got every subject's semantic network the mean network for every semantic field was obtained.

We also obtained individual students' networks (N=25) and a mean network with the data provided by a group of students majoring in English in the first year of English Philology who were studying at the Universidad de Salamanca. They volunteered to participate in this research. The mean net in every group allowed us to infer subjects' knowledge in these lexical groups. The rating task had a duration of approximately 20 minutes.

3. Results and discussion

3.1. Questionnaires

There were many different answers in the questionnaires. We observed a relationship between the number of options given by subjects and the variability in subjects' answers. The larger the percentage students gave for every term or expression, the fewer different forms were obtained in every lexical group (see Appendix D). It was decided that we only would consider the terms or expressions that were given by at least half of the subjects in each semantic field (50%), a cut-off point which tentatively could be considered representative. In this way we only took into account the following terms as nuclei of the lexical groups (given on the left in capitals) for each different level. The terms in bold type are the same given by subjects in the 1st and 2nd questionnaire in the same level.

QUESTIONNAIRE 1	QUESTIONNAIRE 2
First year (N=20) TEMPERATURE: temperature (90%) **WEATHER: weather (90%)** SADNESS: feelings (55%) **TO WALK: movements: (50%)**	First year (N=13) **WEATHER:** precipitation **(61.53%)** **TO WALK:** to walk **(92.30%)** TO LOOK: to see (76.96%) ACTION VERBS: to move (76.96&)
Fourth year (N=21) TEMPERATURE: temperature (71.42%) WEATHER: weather (85.71%) SADNESS: feelings (57.74%) **TO WALK: to walk (66.66%)**	Fourth year (N=16) **TO WALK: to walk (81.25%)** TO LOOK: to see (93.75%) ACTION VERBS: to move (75%) PHYSICAL CONDITION: tired (50%)
Natives (N=8) TEMPERATURE: temperature (62.5%) WEATHER: weather (50%) SADNESS: emotion (50%) **ACTION VERBS: (body) movement (50%)** **TO WALK: to walk (50%)** WORRIEDNESS: emotion (50%)	Natives (N=17) **ACTION VERBS: to move (58.82%)** **TO WALK: to walk (70.58%)**

Table 2: Nuclei of lexical groups.

As we can see in the first questionnaire subjects gave a general term to describe what the lexical group was about independently of their proficiency level in English. They wrote different words or expressions from the ones found in the lexical groups given to subjects. The terms given by at least 50% of the subjects were quite similar in each level group *(temperature, weather, to walk*) with the exception of native speakers, who also gave the nucleus term for two more lexical fields (*ACTION VERBS* and *WORRIEDNESS*). Nonetheless, it should be said that this means an overall moderate agreement, since it is only given for three out of the nine lexical groups (33.33%. On one occasion for the lexical field *SADNESS* one group gave the term *emotion* and the other two the word *feelings*. We did not count it as the same term but we must recognize that they are related from the point of view of semantics).

In questionnaire two, when subjects were instructed to choose one of the terms in the lexical group, there was a lower agreement among level groups than when subjects were free to decide the term or expression which could represent the whole group. In this case we only got an agreement through level groups for two lexical fields: *ACTION VERBS* and *TO WALK* (22.22%).

If we compare the responses in the two questionnaires we see that there is only one time when they coincide. This happens with the semantic field *TO WALK*, whose nucleus is the term itself (11.11%). These percentages are very low and they do not give us information except for one lexical field. As we can see this is not a problem for dealing with the level of knowledge of the language, since it does not yield much difference in the results due to it. It has more to do with the method of collecting data. There was no difference between the two types of instructions in the questionnaires. Probably, when we use direct methods which, as it is shown here, do not provide good results, it could be wiser to use one or the other but not both types of instructions. This is time consuming and does not provide better results.

3.1.1 Similarity ratings

We obtained the mean semantic network for the nine lexical fields with the data provided by English native speakers (N=30), the experts, and also from freshmen students majoring in English (N=25). These are their average nets:

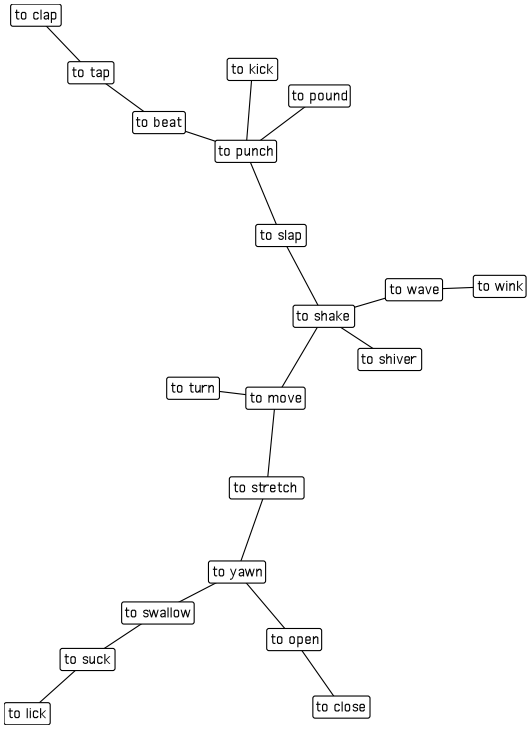

Figure 1: Action verbs. Expert semantic network with parameters q=n-1 and r=infinite

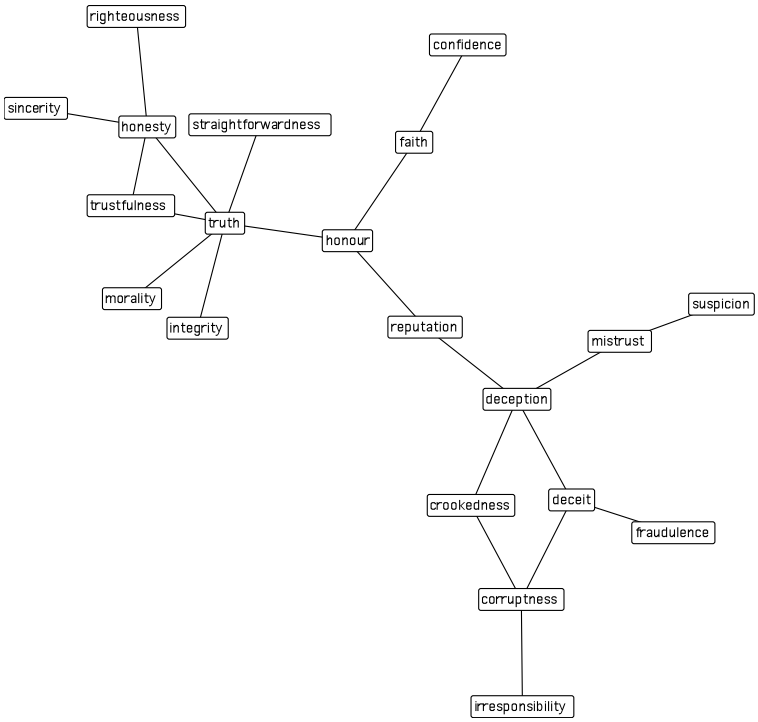

Figure 2: Honour. Expert semantic network with parameters q=n-1 and r=infinite

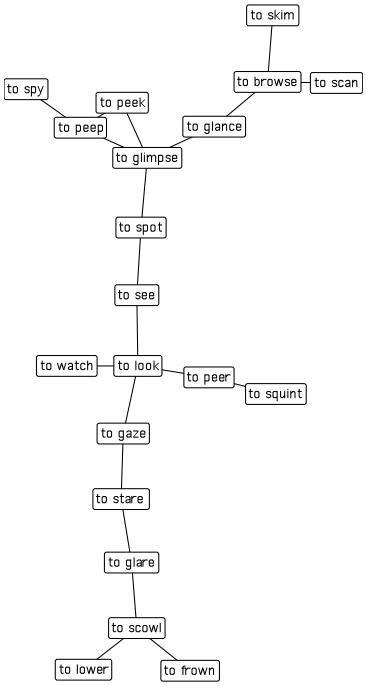

Figure 3: To look. Expert semantic network with parameters q=n-1 and r=infinite

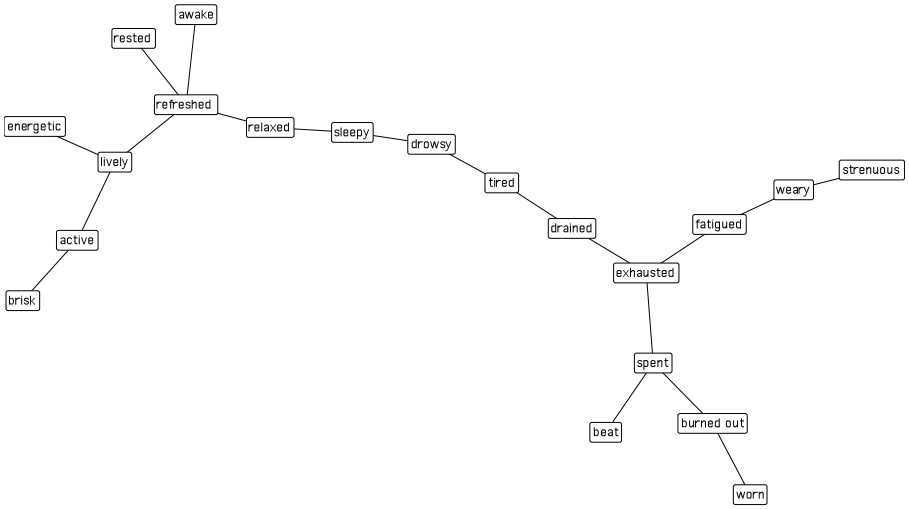

Figure 4: Physical Condition. Expert semantic network with parameters q=n-1 and r=infinite

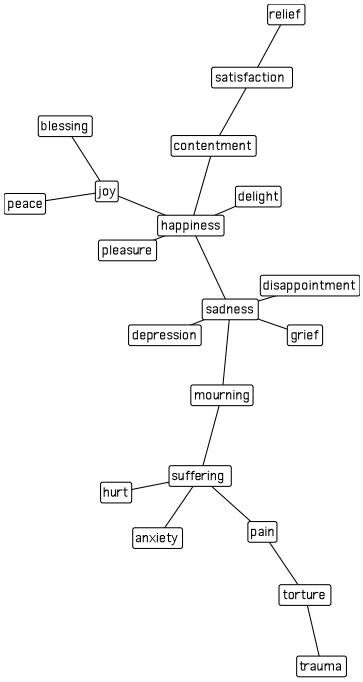

Figure 5: Sadness. Expert semantic network with parameters q=n-1 and r=infinite

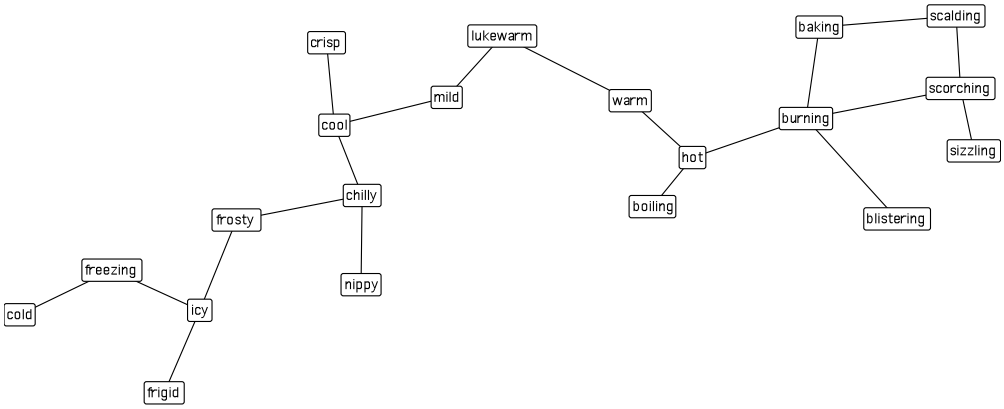

Figure 6: Temperature. Expert semantic network with parameters q=n-1 and r=infinite

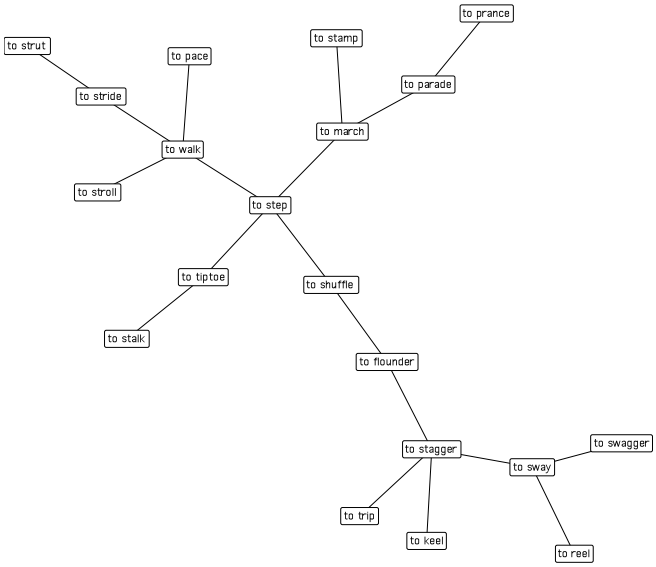

Figure 7: To walk. Expert semantic network with parameters q=n-1 and r=infinite

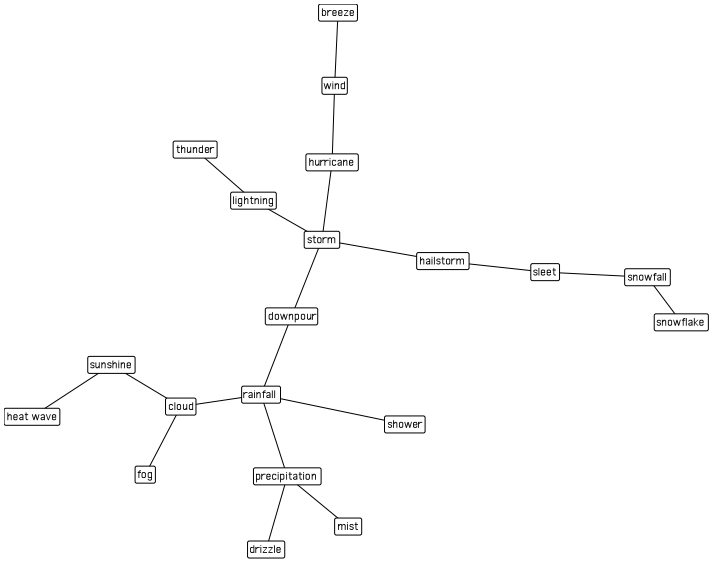

Figure 8: Weather. Expert semantic network with parameters *q=n*-1 and *r*=infinite

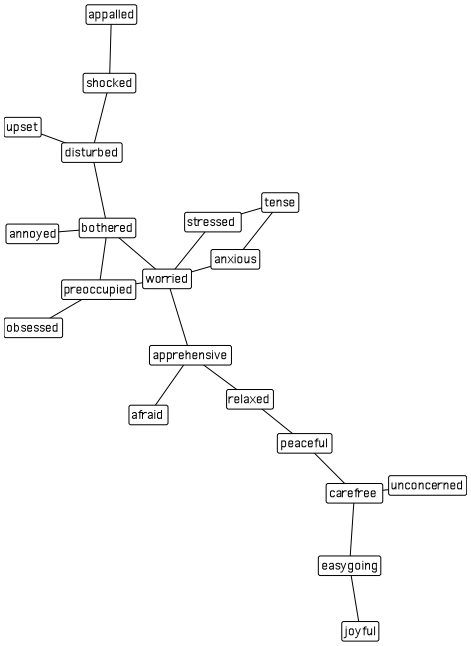

Figure 9: Worriedness. Expert semantic network with parameters q=n-1 and r=infinite

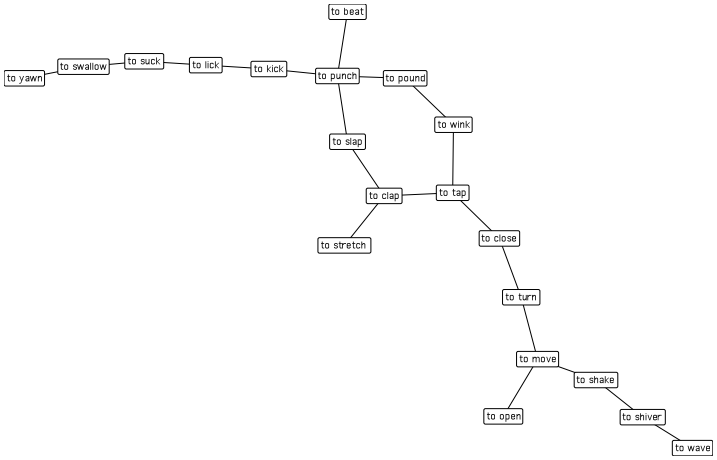

Figure 10: Action Verbs. Mean student semantic network with parameters q=n-1 and r=infinite

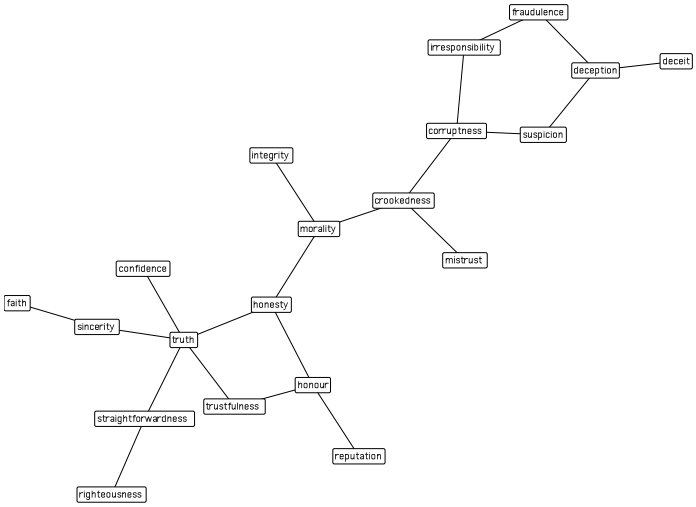

Figure 11: Honour. Mean student semantic network with parameters q=n-1 and r=infinite

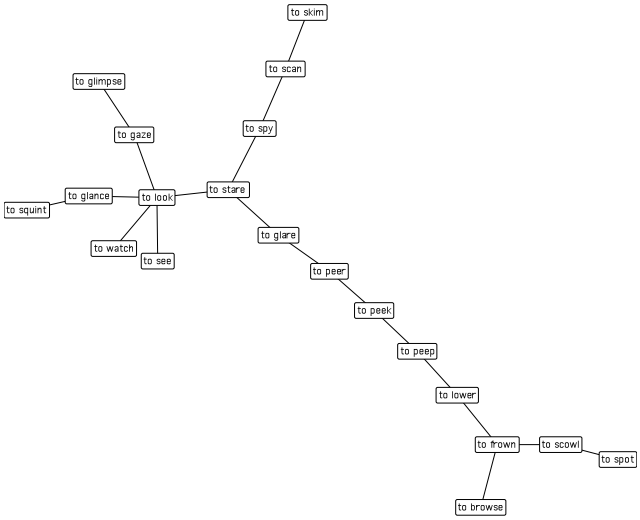

Figure 12: To look. Mean student semantic network with parameters q=n-1 and r=infinite

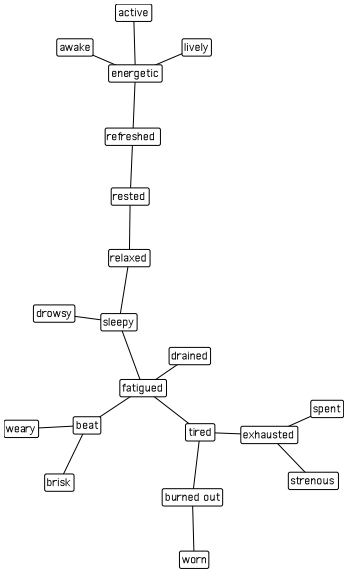

Figure 13: Physical Condition. Mean student semantic network with parameters q=n-1 and r=infinite

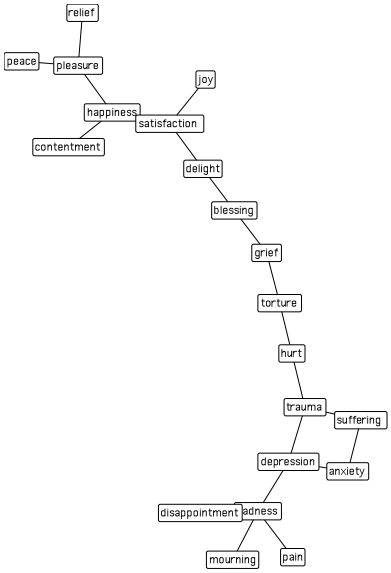

Figure 14: Sadness. Mean student semantic network with parameters q=n-1 and r=infinite

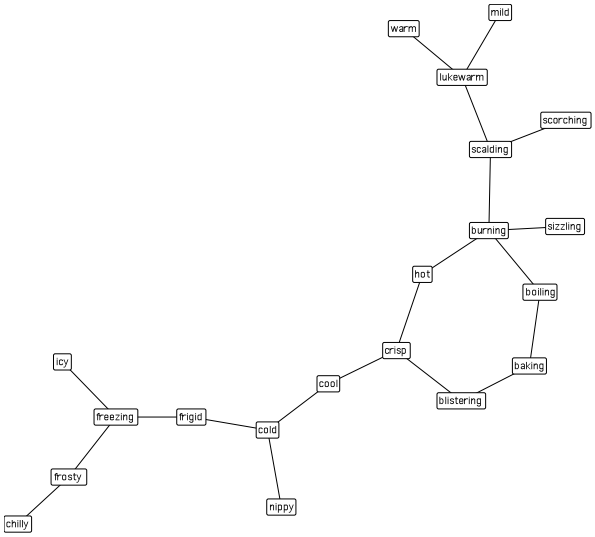

Figure 15: Temperature. Mean student semantic network with parameters q=n-1 and r=infinite

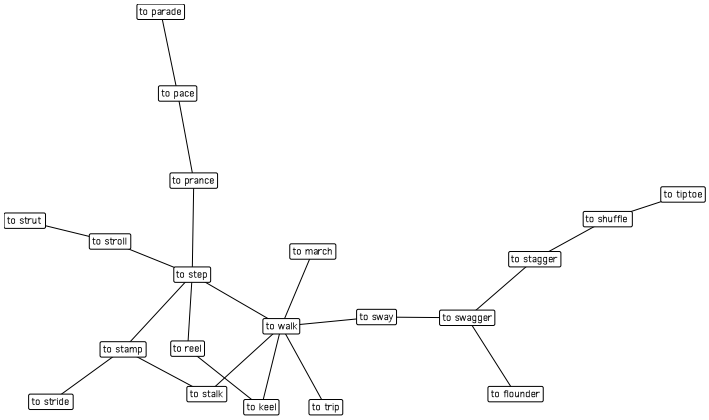

Figure 16: To walk. Mean student semantic network with parameters q=n-1 and r=infinite

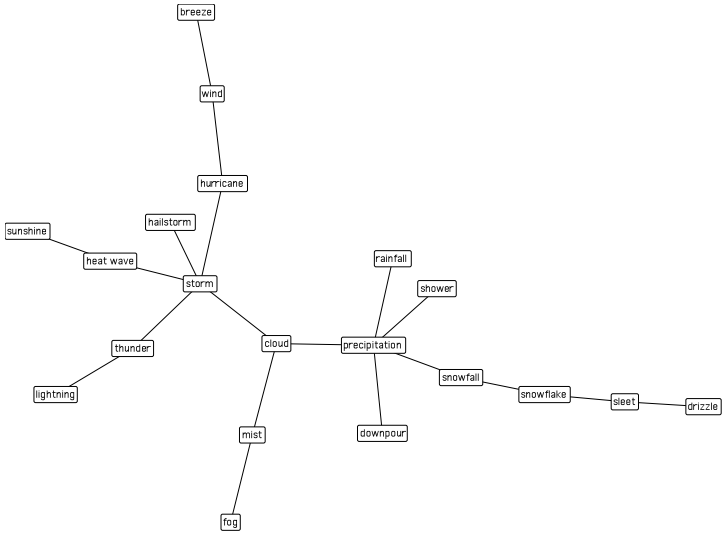

Figure 17: Weather. Mean student semantic network with parameters q=n-1 and r=infinite

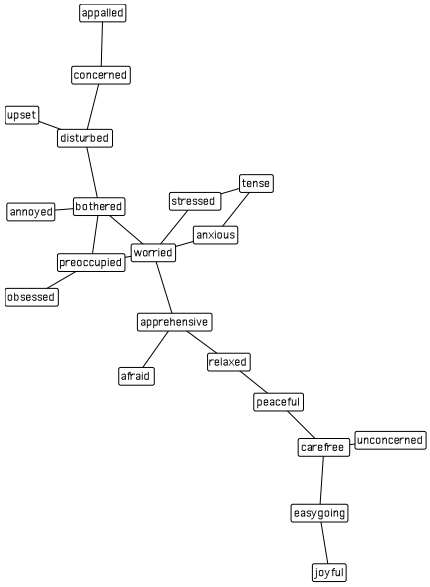

Figure 18: Worriedness. Mean student semantic network with parameters q=n-1 and r=infinite

We can infer which term is the most important and which can represent and name the whole semantic network by counting the number of direct links departing from every node in the network. The one/s with the highest number can be considered the nucleus or the central term (Bajo and Cañas 1992; Bajo and Cañas 1994; Gibson, Bonath and College 1997; Kellogg and Breen 1990; Pitarque and Ruiz 1997; Schvaneveldt *et al*. 1985). If we have a look at the semantic networks obtained with the experts' and students' data we have the following main terms in the nine semantic fields:

LEXICAL FIELDS	EXPERT (Natives)	STUDENTS
ACTION VERBS	to punch (4) to shake (4)	to punch (4)
HONOUR	truth (6)	truth (5)

LEXICAL FIELDS	EXPERT (Natives)	STUDENTS
TO LOOK	to look (4) to glimpse (4)	to look (4)
PHYSICAL CONDITION	refreshed (4)	energetic (4) fatigued (4)
SADNESS	sadness (5) happiness (5)	sadness (4)
TEMPERATURE	burning (4)	burning (5)
TO WALK	to walk (4) to step (4) to stagger (4)	to walk (5) to step (5)
WEATHER	storm (4) rainfall (4)	storm (5) precipitation (5)
WORRIEDNESS	worried (5)	worried (5)

Table 3: Main terms in the nine semantic fields.

The average cognitive representation enabled us to determine the nucleus in every lexical field. It must be said that we obtained the same nucleus in 8 out of the 9 groups under consideration (88.88%). We did not get a common nucleus term for native speakers and for students for the lexical group here called *PHYSICAL CONDITION*. In some other cases the number of links was even the same: *to punch (4)*, *to look (4)*, and *worried (5)*. On some other occasions the nucleus was shared with another term, such as *to punch* and *to shake*, *to look* and *to glimpse*, etc. The centrality, as often happens with semantic networks, can fall on more than one term and when this happens the core, the one which appears in both groups of subjects, can be considered the nucleus. We should probably no longer be talking about *ACTION VERBS* which can refer to many verbs that are completely unrelated to *close, open,* and so on. Unfortunately the same thing happens with *HONOUR, TEMPERATURE*, and several others. Perhaps from now on, we should refer to the lexical groups as follows:

- TO PUNCH (not *ACTION VERBS*)
- TRUTH (not *HONOUR*)
- TO LOOK
- SADNESS
- BURNING (not *TEMPERATURE*)
- TO WALK/TO STEP
- STORM (not *WEATHER*)
- WORRIED (not *WORRIEDNESS*)

If we compare this data with that obtained through direct methods the only matching lexical field is *TO WALK* (nucleus: *to walk,* 11.11%), a very low percentage. Unlike the questionnaires (direct method of extracting knowledge) with the cognitive semantic networks (obtained with an indirect method) we have a very high agreement, even with very different groups, regarding their linguistic proficiency level. This does not mean that these two groups

have a similar net, for if we compared the experts´and students´nets we surely would find a lot of differences in their mental models (Bitter-Rijpkema et al. 2005). Nonetheless, this coincidence leads us to rely more on cognitive task analysis methods and at the same time to ignore our intuitions in favour of empirical studies. Both groups have a specific term that it is likely used with a higher frequency and which fits in more contexts. Maybe this is because of the level of descriptivity that makes them more general terms. It can be stated that the higher the level of descriptivity the higher their frequency (Boas 2008); this is what happens with words like *to walk*, which have a higher degree of descriptivity than other members belonging to the same semantic field, such as *to sway, to tipote*, etc.

4. Conclusions

The main terms obtained with the Pathfinder procedure are reliable, since both groups (experts/students), regardless of their proficiency level, had a very high agreement (88.88%). This, however, did not happen with the ones obtained in the questionnaires. When we reached a consensus with the subjects in the three different groups using restricted instructions, this was limited to two lexical fields: *ACTION VERBS* (nucleus: *to move*) and *TO WALK* (nucleus: *to walk*), and only the last one coincides with the central term (*to walk*) obtained with an empirical methodology. Needless to say that when subjects were instructed in a non-restrictive way what they did was to choose a very general term to describe the semantic field. This is what we, teachers and researchers, also did to name the nine semantic fields relying on our knowledge, which as we have shown in this research is erroneous. We should not rely, either, on linguists or professionals dealing with the English language since our intuitive denominations of several of these lexical fields, namely *ACTION VERBS, HONOUR, TO LOOK*, etc. were not confirmed through indirect methods. This knowledge allows us to reject our erroneous beliefs and also to know which is the essential vocabulary that our students should master regardless of the order of the terms in the familiarity lists (e.g. for the semantic field related to the lexical field we called at the beginning *ACTION VERB*S the first noun we should know is *to punch* even though it is in 17th place. Same thing happens in the lexical fields related to *PHYSICAL CONDITION* and *SADNESS* terms with the nucleus *refreshed* and *sadness* which appear in the 13th and 14th position respectively in spite of being the central terms). This information is relevant to ESL teaching because it allows teachers to know the main terms and connections students should know (Lin 1997; Meara 2007; Vives Boix and Meara 1994).

We can consider direct methods for the purpose of obtaining initial information for making research materials up dealing with vocabulary. However, we should focus more on indirect methods for knowledge elicitation and for extracting vocabulary knowledge that experts cannot explicitly retrieve.

References

Bajo, M. T and J. J. Cañas. 1992. Knowledge organization and memory retrieval. *5th Conference, European Society for Cognitive Psychology*. Paris.

Bajo, M. T and J. J. Cañas. 1994. Métodos indirectos de adquisición del conocimiento. In P. Adarraga and J. L. Zaccagnini (eds.), *Psicología e Inteligencia Artificial*. 211-240. Madrid: Trotta.

Beissner, K., D. H. Jonassen and M. Yacci. 1993. *Structural Knowledge: Techniques for Representing, Conveying and Acquiring Structural Knowledge.* Hillsdale: Lawrence Erlbaum.

Bitter-Rijpkema, M., R. Martens and W. Jochems. 2005. Elicitation support requirements of multi-expertise teams. *Journal of Interactive Learning Research* 16: 133-154.

Boas, H. C., 2008. Identifying semantically relevant units of meaning. *26th International AESLA Conference*. Almería.

Burge, J. E. 2008. Knowledge elicitation tool clasification. Artificial Intelligence Research Group, Worcester Polytechnic Institute. http://web.cs.wpi.edu/~jburge/thesis/kematrix.html, retrieved February 26, 2008.

Cañas, J. J., M. T. Bajo, R. Navarro, F. Padilla and M. C. Puerta. 1998. Representación mental y programación de ordenadores. *Cognitiva* 10: 239-255.

Computational Memory Lab. http://fechner.ccs.brandeis.edu/wordpools/kfpool.txt

Cooke, N. J. 1992. Predicting judgment time from measures of psychological proximity. *Journal of Experimental Psychology: Learning, Memory, and Cognition* 18: 640-653.

Cooke, N. J. 1994. Varieties of knowledge elicitation techniques. *International Journal of Human-Computer Studies* 41: 801-849.

Cooke, N. M., F. T. Durso, R. W. Schvaneveld. 1986. Recall and measures of memory organization. *Journal of Experimental Psychology: Learning, Memory, and Cognition* 12: 538-549.

Cooke, N. M. and R. W. Schvaneveldt. 1988. Effects of computer programming experience on network representations of abstract programming concepts. *International Journal of Man-Machine Studies* 29: 407-427.

Gammack, J. G. and R. M. Young. 1985. Psychological techniques for eliciting expert knowledge. In M. A. Brammer (ed.), *Research and Development in Expert Systems*. 105-112. Cambridge: Cambridge University Press.

Gibson, J. M., G. J. Bonath and G. College. 1997. Experts' and novices' mental models of an online catalog. Poster presented at the 38th Conference of The Psychonomic Society, Philadelphia, Pennsylvania.

Goldsmith, T. E., P. J. Johnson, W.H. Acton. 1991. Assessing structural knowledge. *Journal of Educational Psychology* 83: 88-96.

Gonzalvo, P., J. J. Cañas and M. T. Bajo. 1994. Structural representations in knowledge acquisition. *Journal of Educational Psychology* 86: 601–616.

Housner, L. D., R. L. Gomez and D. C. Griffey. 1993. A Pathfinder analysis of expert-novice knowledge. *Proceedings of the Meeting on the National American Alliance for Health, Physical Education, Recreation and Dance* 64: Supplement: A88- A89.

Johnson, P. J., T. E. Goldsmith and K. W. Teague. 1995. Similarity, structure, and knowledge: a representional approach to assessment. In P. D. Nichols, S. F. Chipman and R. L. Brennan (eds.), *Cognitively Diagnostic Assessment*. 221–249. Hillsdale: Lawrence Erlbaum.

Kellogg, W. A. and T. J. Breen. 1990. Using Pathfinder to evaluate user and system models. In R. W. Schvaneveldt (ed.), *Pathfinder Associative Networks: Studies in Knowledge Organization*. 179-195. Norwood: Ablex Publishing Corporation.

Lin, C. 1997. Semantic network for vocabulary teaching. *Journal of Taiwan Normal University: Humanities & Social Sciences* 42: 43-54.

Márquez Sánchez, M. O. and D. Muñoz Cáceres. 1994. La entrevista. In P. Adarraga and J. L. Zaccagnini (eds.), *Psicología e Inteligencia Artificial*. 187-209. Madrid: Trotta.

McDonald, J. E., T. Dayton and D. R. McDonald. 1988. Adapting menu layout to tasks. *International Journal of Man-Machine Studies* 28: 417-436.

Meara, P. 2007. Simulating word associations in an L2: The effects of structural complexity. *Language Forum* 33: 13-31.
Pitarque, A. and J. C. Ruiz. 1997. Representación del conocimiento estructural tras el entrenamiento en esquemas procedimentales. *Psicológica* 18: 11-21.
Richards J. C., R. Schmidt, H. Kendricks and Y. Kim. 2002. *Longman Dictionary of Language Teaching and Applied Linguistics*. London: Longman.
Rowe, A. L., N. J. Cooke, E. P. Hall and T. L. Halgren. 1996. Toward an on-line knowledge assessment methodology: Building on the relationship between knowing and doing. *Journal of Experimental Psychology: Applied* 2: 31-47.
Sánchez, M. J., L. M. González and M. L. Escobar. 2003. Los campos semánticos. Su formación. *XXVII International Conference of AEDEAN*. Universidad de Salamanca, Salamanca.
Schvaneveldt, R.W. 1990. *Pathfinder Associative Networks: Studies in Knowledge Organization*. Norwood: Ablex Publishing Corporation.
Schvaneveldt, R.W., F. T. Durso and D. W. Dearholt. 1989. Network structures in proximity data. In G. H. Bower (ed.), *The Psychology of Learning and Motivation: Advances in Research and Theory*. 249–284. New York: Academic Press.
Schvaneveldt, R.W., F. T. Durso, T. E. Goldsmith, T. J. Breen, N. M. Cooke, R. G. Tucker and J. C. De Maio. 1985. Measuring the structure of expertise. *International Journal of Man-Machine Studies* 23: 699–728.
Thompson, L. A., R. L. Gomez and R. W. Schvaneveldt. 2000. The salience of temporal cues in the developing structure of event knowledge. *American Journal of Psychology* 4: 591-619.
Villachica, S. W., L. L. Lohr, L. Summers, N. Lowell, S. Roberts, M. Javeri, E. Hunt and C. Mahoney. 2001. A cognitive map of human performance technology: A study of domain expertise. *Annual Proceedings of Selected Research and Development [and] Practice Papers* 1-2: 437-444.
Vives Boix, G. and P. Meara. 1994. Word associations in Spanish. *Vida Hispánica* 10: 12-22.
WordNet (Lexical Database of the English Language). http://www.cogsci.princeton.edu/cgi-bin/webwn1.7.1

Appendix A. Questionnaire 1
LAST NAME …… FIRST NAME …….

COUNTRY ……..

Which term would you use to designate each of these lexical fields? You can use one of the terms included in the list or another term/expression you think is appropriate. Your choice should depend on relevance, frequency and number of links that could be established.

_____
to close, to open, to stretch, to suck, to swallow, to turn, to beat, to clap, to kick, to move, to slap, to wave, to wink, to yawn, to lick, to pound, to punch, to shake, to shiver, to tap

_____
energetic, exhausted, sleepy, tired, active, beat, drowsy, relaxed, rested, awake, burned out, lively, refreshed, drained, fatigued, spent, strenuous, weary, worn, brisk

_____
to stamp, to trip, to walk, to step, to stroll, to stalk, to stride, to tiptoe, to parade, to strut, to march, to pace, to prance, to shuffle, to stagger, to sway, to swagger, to flounder, to keel (over), to reel

_____
afraid, annoyed, bothered, disturbed, easy, obsessed, preoccupied, stressed, upset, worried, anxious, concerned, peaceful, relaxed, appalled, apprehensive, tense, unconcerned, carefree, joyful

_____
faith, honesty, hono(u)r, irresponsibility, truth, integrity, morality, sincerity, trustfulness, confidence, corruptness, deception, fraudulence, suspicion, deceit, mistrust, righteousness, reputation, crookedness, straightforwardness

_____
boiling, burning, cold, cool, chilly, freezing, hot, icy, warm, crisp, mild, frosty, baking, scalding, scorching, sizzling, frigid, lukewarm, blistering, nippy

_____

to see, to stare, to watch, to browse, to glance, to glare, to gaze, to spy, to squint, to look, to glimpse, to peek, to skim, to frown, to scan, to spot, to peep, to lower (eyes), to peer, to scowl

_____

cloud, drizzle, fog, heat wave, hurricane, lightning, precipitation, rainfall, storm, sunshine, thunder, wind, breeze, shower, sleet, snowflake, downpour, hailstorm, mist, snowfall

_____

anxiety, sadness, depression, happiness, hurt, pain, peace, pleasure, relief, satisfaction, blessing, delight, joy, mourning, torture, contentment, disappointment, grief, suffering, trauma

Appendix B. Questionnaire 2
LAST NAME …… FIRST NAME …….

COUNTRY ……..

Which term would you use to designate each of these lexical fields? Use one of the terms included in every group of words. Your choice should depend on relevance, frequency and number of links that could be established.

(SAME TERMS AS IN QUESTIONNAIRE 1)

Appendix C. Pathfinder procedure

The quotation taken from Thompson, Gomez and Schvaneveldt (2000: 259-596) gives a clear idea about what the Pathfinder procedure is:

> It has been used to investigate knowledge structure in a number of domains, including adult memory (Cooke, 1992; Cooke et al., 1986; Cooke and Schvaneveldt, 1988), learning (Gomez and Schvaneveldt, 1994), and assessment of knowledge growth (Goldsmith et al., 1991; Gomez et al., 1996)… The Pathfinder network scaling algorithm generates empirically derived network representations of the associative structure among a set of concepts by taking psychological estimates of distance (e.g., relatedness ratings) as input and outputting a graphic representation of a persons' semantic network (Schvaneveldt, 1990; Schvaneveldt et al., 1989). Each concept in the network is represented by a node, and the relationships between concepts are represented by links between nodes… Readers familiar with work on cognition will recognize the relationship between Pathfinder networks and semantic networks (Collins and Loftus, 1975; Meyer and Schvaneveldt, 1976; Quillian, 1969). However the primary method for constructing semantic networks is theoretical, whereas Pathfinder generates networks empirically from estimates of psychological distance. We assume that the resulting associative structures reflect knowledge of people, actions, or objects related to events.
> (Thompson et al., 2000: 595-596).

Besides the references already mentioned it is also worth considering the research carried out by Gonzalvo et al. (1994), Pitarque and Ruiz (1997) and by Villachica et al. (2001).

First year (N=20)													
HONOUR	3 morality	3 behaviour	2 friendship	2 qualities	1 state	1 personality	1 description	1 adjectives	1 humanity	1 virtues	1 integrity	1 nature	1 characteristics
TEMPERATURE	18 temperature	1 water	1 weather										
TO LOOK	5 see	5 sight	2 vision	2 look	1 verbs	1 gestures	1 observate	1 watching	? 1				
WEATHER	18 weather	1 atmosphere	1 nature										
SADNESS	11 feelings	2 ill/sickness	2 psych. State	2 mood	1 mental situation	1 adjectives	1 sensations						
A. VERBS	9 movements	3 verbs	2 actions	1 close	1 infinitives	1 go out	1 confusion	? 2					
P. CONDITION	3 feelings	3 energy	3 adjectives	2 tired	2 physical condition	1 live	1 qualities	1 anton./synonyms	1 bed	1 states	1 will		
TO WALK	10 movements	7 walk	1 confusion	1 country	? 1								
WORRIEDNESS	9 feelings	3 adjectives	2 mood	1 worriedness	1 positive/negative	1 fears	1 state	1 emotions	1 personality				
Fourth year (N=21)													
HONOUR	6 abstract nouns	4 morals	3 personality	2 reputation	2 qualities	1 honesty	1 honour	vices & virtues 1	trustfulness 1				
TEMPERATURE	15 temperature	? 2	1 water	1 cold	1 physical effect	1 weather							
TO LOOK	9 see	5 look	3 sight	2 observe	2 observe	1 eye reaction	1 senses						
WEATHER	18 weather	1 nature	1 climate	1 meteorology									
SADNESS	12 feelings	5 st. of mind	1 mood	1 un/happiness	1 illness	1 abstract nouns							
A. VERBS	9 to move	4 actions	2 verbs	? 2	1 dynamic verb	1 body verb	1 lexical verbs	1 to live					
P. CONDITION	5 physical state	3 tiredness	3 fitness	? 2	2 active/passive	2 body state	1 energetic	1 exhausted	1 psycho. State	1 how you feel after class			
TO WALK	14 walk	6 movement	? 1										
WORRIEDNESS	4 adjectives	4 feelings	? 3	2 emotion	2 state	2 mood	1 concerned	1 way of being	1 bothered	1 preocupation			
Natives (N=8)													
HONOUR	1 honesty	1 truth	1 fake	1 characteristics	1 emotion	1 faith	1 ethics	1 morality					

TEMPERATURE	5 temperature	1 heat	1 stuffy	1 hot/cold									
TO LOOK	3 look	2 see	1 sight	1 wink	? 1								
WEATHER	4 weather	1 blizzard	1 meteorology	2 precipitation									
SADNESS	4 emotion	3 feelings	1 shock										
A. VERBS	4 body movement	2 move	1 action	1 munch									
P. CONDITION	2 tired	1 physical condition	1 hyperactive	1 mood	1 energy	1 awake	1 result of life						
TO WALK	4 walk	2 movement	1 skip	1 trudge									
WORRIEDNESS	4 emotion	1 feelings	1 patient	1 bothered	1 describe personality								

Appendix D: Questionnaire 1. Results. *? means that the subject did not write a word.*

First year (N=13)										
HONOUR	3 honour	2 truth	2 honesty	2 morality	1 integrity	1 sincerity	1 reputation	1 straightforwardness		
TEMPERATURE	4 cold	3 warm	2 hot	1 mild	1 boiling	1 blistering	1 cool			
TO LOOK	10 see	2 look	1 watch							
WEATHER	8 precipitation	2 storm	1 wind	1 hurricane	1 cloud					
SADNESS	4 sadness	4 contentment	2 pain	1 suffering	1 disappointment	1 satisfaction				
A. VERBS	10 move	1 beat	1 shake	1 turn						
P. CONDITION	4 energetic	3 active	2 lively	1 drowsy	1 awake	1 burned out	1 tired			
TO WALK	12 walk	1 trip								
WORRIEDNESS	5 worried	2 tense	2 upset	1 joyful	1 proccupied	1 bothered	1 concerned			
Fourth year (N=16)										
HONOUR	6 truth	5 honesty	2 morality	1 integrity	1 confidence	? 1				
TEMPERATURE	7 hot	4 warm	2 cold	1 chilly	1 cool	? 1				
TO LOOK	15 see	1 look								
WEATHER	5 precipitation	4 storm	2 sunshine	2 breeze	1 cloud	1 shower	1 downpour			
SADNESS	4 relief	3 happiness	3 sadness	2 pleasure	2 peace	1 suffering	1 contentment			
A. VERBS	12 move	2 open	1 close	? 1						
P. CONDITION	8 tired	4 lively	2 active	1 energetic	1 rested					
TO WALK	13 walk	2 march	1 stroll							
WORRIEDNESS	6 worried	3 concerned	3 easy	1 carefree	1 upset	1 afraid	? 1			
Natives (N=17)										
HONOUR	5 reputation	3 truth	3 integrity	1 sincerity	1 morality	1 faith	1 confidence	1 honesty	1 righteousness	
TEMPERATURE	4 mild	2 lukewarm	2 nippy	2 crisp	2 baking	1 frosty	1 cold	1 icy	1 blistering	1 warm
TO LOOK	7 see	5 look	2 watch	1 spy	1 peep	1 scowl				
WEATHER	7 precipitation	4 storm	3 cloud	1 hurricane	1 snowflake	1 downpour				
SADNESS	3 contentment	3 satisfaction	3 trauma	2 depression	1 hurt	1 relief	1 peace	1 disappointment	1 suffering	1 joy
A. VERBS	10 move	2 beat	2 wink	1 tap	1 pound	1 close				

P. CONDITION	5 awake	2 weary	2 active	2 fatigued	1 tired	1 beat	1 refreshed	1 worn	1 sleepy	1 rested
TO WALK	12 walk	2 pace	1 stagger	1 keel (over)	1stamp					
WORRIEDNESS	4 preoccupied	3 concerned	2 tense	2 apprehensive	1 peaceful	1 upset	1 appalled	1 stressed	1 disturbed	1 apprehensive

Appendix D: Questionnaire 2. Results. ? means that the subject did not write a word.