

LEARNING TRANSLATION SKILLS WITH A KNOWLEDGE-BASED TUTOR:
FRENCH-ITALIAN CONJUNCTIONS IN CONTEXT

Stefano A. Cerri

Dipartimento di Informatica, Università di Pisa
56100 Pisa, Italy

Marie-France Merger

Dipartimento di Lingue e Letterature Romanze, Università di Pisa
56100 Pisa, Italy

ABSTRACT

This paper describes an "intelligent" tutor of foreign language concepts and skills based upon state-of-the-art research in Intelligent Teaching Systems and Computational Linguistics.

The tutor is part of a large R&D project in ITS which resulted in a system (called DART) for the design and development of intelligent teaching dialogues on PLATO¹ and in a program (called ELISA) for teaching foreign language conjunctions in context. ELISA was able to teach a few conjunctions in English, Dutch and Italian. The research reported here extends ELISA to a complete set of conjunctions in Italian and French.

I. INTRODUCTION

In the framework of a large research and development project - called DART - concerned with the construction of an environment for the design of large scale Intelligent Teaching Systems (ITS), a prototype ITS - called ELISA - was developed which teaches words (conjunctions) of a foreign language in context (Cerri & Breuker, 1980, 1981; Breuker & Cerri, 1982).

The DART system is an authoring environment based on the formalism of ATNs for the representation of the procedural part of the teaching dialogue and on Semantic Networks for the representation of the conceptual and linguistic structures. The main achievement of DART was the integration of traditional Computer Assisted Learning (CAL) facilities - such as the ones available in the PLATO system - in an Artificial Intelligence framework, thus offer-

¹ The DART system on PLATO is the result of a joint effort of the University of Pisa (I) and the University of Amsterdam (NL) and its property rights are reserved. It can be distributed for experimentation and research.

* This work was partially financed by a grant of the GRIS group of the Italian National Research Council.

ing authors a friendly environment for a smooth CAL - ITS transition when they design and develop teaching programs.

ELISA was a testbed of the ideas underlying the DART project and at the same time a simple, but operational, "intelligent" foreign language teacher acting on a small subset of English, Dutch and Italian conjunctions. The sample dialogues of ELISA were chosen intentionally to exemplify, in the clearest way, issues such as the diagnostic of misconceptions in the use of foreign language conjunctions, which were addressed by the research. In particular, the assumption was made that a very simple representation of the correct knowledge needed for using f.l. conjunctions in context would have been sufficient to model the whole subject matter as well as the incorrect behaviour of the student.

Owing to its prototypical and experimental character, ELISA was not ready for concrete, large scale experimentation on any pair of the languages mentioned.

The research described in this report has been carried out with the concrete goal of making ELISA a realistic "intelligent" automatic foreign language teacher. In fact, we wanted to verify whether the simple representation of the knowledge in a semantic network was sufficient to represent a complete set of transformations from the first into the second language and vice versa.

Italian and French were chosen. A complete contrastive representation of the use of conjunctions in meaningful contexts was produced.

The set of these unambiguous, meaningful contexts - about 600 - defines the use of the conjunctions - about 40 for each language. Their correct use can be classified according to 60 distinguishing "concepts" which provide for all potential translations.

The classification was done on an empirical ground and is not based on any linguistic rule or theory. This was actually a contrastive bottom-up analysis of the use of conjunctions in Italian and

French.

The specific choice of the teaching material highlighted many (psycho)linguistic and computational problems related to the compatibility between the design constraints of ELISA on the one hand and the subtleties of the full use of natural language fragments in translations on the other. In particular, the complexity of the full network of conjunctions, concepts and contexts in the two languages suggests a large set of possible misconceptions to be discovered from the (partially) incorrect behaviour of the students but only the subset of plausible ones should guide the diagnostic dialogue.

In the following, we briefly present the teaching strategy of ELISA and some examples of dialogue in order to introduce the problems referred above and the solutions we propose.

The full set of data is available in Merger & Cerri (1983) and a subset of it as well as a more extended description of this work can be found in Cerri & Merger (1982). A detailed description of DART and ELISA is a work in preparation.

Notice that for the development of this knowledge base no other expertise was required than that of a professional teacher, once the principles are provided by AI experts. This is a proof of the potential power of AI representations in educational settings and in projects of natural language translation.

Practically, our program is one of the few Intelligent Systems available in the field of Foreign Language Teaching and usable on a large scale for Computer Assisted Learning.

II ELISA : A RATHER INTELLIGENT TUTOR OF FOREIGN LANGUAGE WORDS

A. The Purpose of ELISA

ELISA teaches a student to disambiguate conjunctions in a foreign language by means of a dialogue. The purpose of ELISA's dialogue is to build a representation of the student's behaviour which coincides with the correct representation of the knowledge needed to translate words in a foreign language in context.

ELISA has a student model, which is updated each time the student answers a question. According to the classification of the answer, and the phase of the dialogue, ELISA selects one or more new questions to be put to the student in order to achieve its purpose.

The mother and the foreign language can be associated to the source and the target language (s.l. and t.l.) respectively, or vice versa: the

system is symmetric.

The main phases of ELISA are **Presentation** and **Assessment**.

B. The Presentation Phase

The presentation phase is traditional. The teacher constructs an exhaustive set of **Question Types** from the subject matter represented in a knowledge network containing conjunctions and contexts in two languages as well as concepts adequately linked to conjunctions and contexts (see for instance Figs.1 and 2). These are pairs: conjunction in the source language/conceptual meaning. For each conjunction in the s.l. and each concept possibly associated to it a question type is generated.

For each question type, a classification of the conjunctions in the target language may be constructed. This classification is a partition of the t.l. conjunctions into three classes, namely expected right, expected wrong and unexpected wrong. The **Expected Right** conjunctions are all t.l. conjunctions which can be associated to the conceptual meaning of the question type. The **Expected Wrong** conjunctions are all t.l. conjunctions which can be a correct translation of the s.l. conjunction of the question type, but in a conceptual meaning different from that of the question type considered. The remaining conjunctions in the t.l. are classified as **Unexpected Wrong**: they do not have any relation in the knowledge base with the s.l. conjunction, nor with the concept in the question type considered.

Notice that "concepts" are defined pragmatically i.e. in terms of the purpose of the representation which is to teach students to translate correctly conjunctions in context. This definition of concepts is not based on any (psycho)linguistic theory or phenomenon. In fact, we looked for contexts which have a one-to-one correspondence with concepts, so that for each context all the conjunctions associated to its specific conceptual meaning can be valid completions of the sentence, in both languages.

The question is generated from the question type by selecting (randomly) a context linked to the concept of the question type, and inserting the conjunction of the question type. One of the (equivalent) translations of the context into target language is also presented to the student. The student is required to insert the conjunction in the target language which correctly completes the sentence.

When the student makes an error, the correction consists simply in informing him/her of the correct answer(s). This feedback strategy should have the effect of teaching the student the correct

associations and is similar to that used in most CAL programs.

In contrast to most CAL programs, in ELISA questions are generated at execution time from information stored in the knowledge network. The classification of answers is computed dynamically from the knowledge network, it is not a simple local pattern matching procedure.

C. The Assessment Phase

The purpose of the assessment phase is to verify the acquisition of knowledge and skills on the part of the student during the presentation phase. It includes the diagnosis and remedy of misconceptions.

Questions are generated as in the presentation phase, but in case of a consistent incorrect answer - a bug (see for instance Brown & van Lehn, 1980), - a complete dialogue with the student is performed in order to test the hypothesis that the bug arises from a whole set of errors grouped into one or more misconceptions.

The procedure operates briefly as follows: each bug invokes

- a. one concept called **Source Misconcept** which represents the meaning of the context of the question put to the student (e.g., conditional, temporal, etc.), and
- b. one or more concepts called **Target Misconcepts** which represent the possible meanings of the conjunction used by the student in the answer. The set of target misconcepts does not include the source misconception by definition of the bug.

For each pair of source/target misconception, question types are generated and the questions are in turn put to the student. The selection of adequate question types is done on the basis of the **Possible** misconception(s); a more skilled selection should include constraints about the **Plausible** (expected) misconceptions, instead of considering exhaustively all the theoretical combinations. This is a main issue of further empirical research, as will be remarked later.

During each of these diagnostic dialogues, it is possible that new bugs, i.e. bugs not related to the source and target misconception, are discovered. When this is the case, these bugs are stored in a bug stack. Once the original misconception has been diagnosed and remedied, each bug in the bug stack triggers (recursively) the same diagnostic procedure.

Again, a more skilled strategy for the ordering of bugs to be diagnosed and remedied could be easily designed, on the basis of empirical evidence drawn by experiments on student's behaviour.

Finally, let us discuss in more detail the evaluation of the student model as it was built according to a diagnostic dialogue. By "student model", we mean the set of "misconception matrixes" each related to the source and a target misconception, and related to two or more conjunctions.

As these matrixes may, in principle, present a large variety of different patterns, and even allow for variations in their dimensions, it would be a rather complex task to design a minimal set of typical erroneous patterns unless some reduction procedure is applied.

So, we first compress the misconception matrixes into "confusion kernels" which are (2x3) matrixes, then we compare the kernels with standard patterns of stereotypical misconceptions. Once the match is found, the diagnostic phase is considered ended, and a remedy phase is begun.

The remedy consists in informing the student of the "nature of the misconception", i.e. the interpretation of the confusion kernel. This interpretation is possible by applying some (psycho)linguistic criteria. In the following section, some of these criteria will be outlined in order to explain the behaviour of ELISA in the examples of dialogue presented.

In other words, the remedy is not a paraphrase of the history of the dialogue during the diagnosis, but an interpretation of the significant aspects of that dialogue. Although the ELISA project is to be considered completed, research is currently carried out in order to design a cognitively grounded theory of misconceptions occurring in this translation task. For some preliminary work, see Breuker & Cerri (1982).

It should be noticed that this is the most delicate aspect of this investigation. When ELISA was in a preliminary phase, and its dialogues were realistic but limited to a "toy" knowledge about the discriminative use of a few conjunctions, we did not expect that its extension to "real" knowledge would have implied such an explosion of possible right (and wrong) links in the network, thus implying an explosion of possible models of student's behaviour. Now, the reduction of the number and complexity of these possible models requires undoubtedly empirical evidence. Currently, ELISA embodies enough intuitions to be considered a mature experimental tool, but not a complete theory of behaviour in translation, which will only be possible after many refinements of the simple theory embodied by ELISA according to the experimental evidence in real educational settings.

After a misconception has been remedied, the (new) bug stack is examined and each bug triggers a diagnostic-remedial procedure, possibly suggesting

new bugs and so recursively.

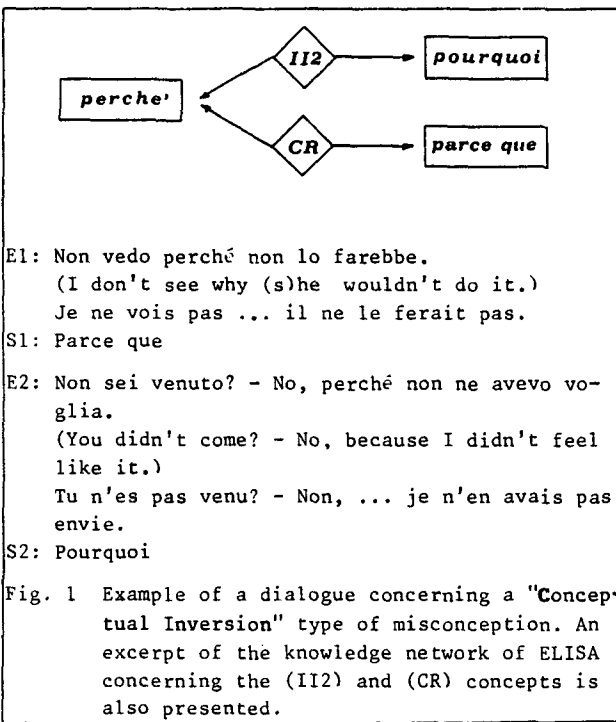
When a (new) bug stack is empty, ELISA checks if all pairs of source/target misconcept have been examined, if it was not the case a diagnostic procedure is called, else the (original) bug is considered remedied and ELISA formulates once more the question which received initially the wrong answer. We expect that now the student will not fail.

III STEREOTYPICAL PROTOCOLS OF DIALOGUE

In this section we will present some examples of dialogue which may well represent a typical interaction occurring as diagnosis and remedy of a student's misconceptions.

A. Conceptual Inversion

The dialogue in Fig. 1 presents a prototype for a class of misconceptions which may be classified as "conceptual inversion", i.e. the model of the student represents the fact the (s)he distinguishes between the source and target misconcept, but associates each of the two with a conjunction specific for the other of the two.



In this example, the first question of ELISA: E1 has the type (perché, (II2)²) and the expected right answer is "pourquoi".

² (II2) means: 'Indirect Interrogation, 2nd type'.

Usually, students know that "pourquoi" is correct in interrogative clauses, but sometimes they do not know that an interrogative clause might be indirect, as is our case. Therefore, the translation "pourquoi" is discarded, and the alternative "parce que" preferred. This conjunction is indeed a correct translation of "perché", but in (CR)³ contexts. This bug is classified as "expected wrong" and the diagnostic strategy is entered.

The question E2 of ELISA checks if the student knows that the translation of "perché" in (CR) contexts is "parce que". If this is the case, it could be guessed that the student does not know (the use of) "pourquoi", or alternatively knows (the use of) "pourquoi" but believes "pourquoi" to be correct in a meaning different from (II2) or (CR), and translates "perché" with "parce que" irrespective of the context. This misconception will be described in more detail in the next subsection.

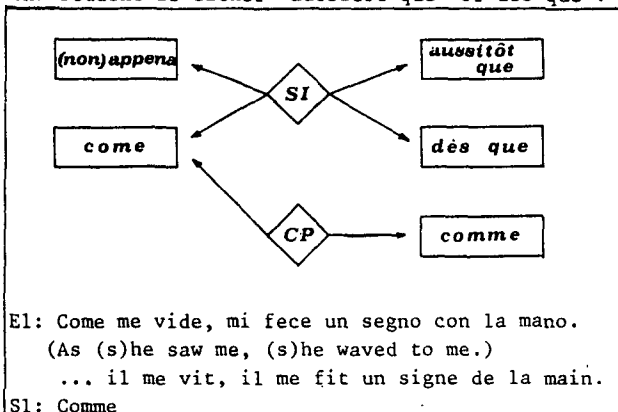
Instead, the student answers: "pourquoi" which allows one to draw the following conclusions:

- the student distinguishes between (II2) and (CR) contexts, but
- (s)he binds (II2) with "parce que" and (CR) with "pourquoi", which is the reverse of the correct knowledge about French conjunctions.

We call this misconception **Conceptual Inversion**, the remedy of ELISA will explain to the student this result and give more examples of the use of these conjunctions as translations of "perché" in each of the two conceptual meanings.

B. Direct Translation

The second example refers to the dialogue presented in Fig. 2. The question type of E1 is: (come, (SI)⁴), and the expected right response of the student is either "aussitôt que" or "dès que".



³ (CR) means: 'Real Cause'

⁴ (SI) means: 'Immediate Succession of the two processes'.

E2: Non appena so qualcosa, Le telefono.
 (As soon as I know something, I'll phone you.)
 ... je sais quelque chose, je vous téléphone.
 S2: Dès que
 E3: Sono arrivato per tempo, come vedi.
 (I arrived in time, as you see.)
 Je suis arrivé à temps, ... tu vois.
 S3: Comme

Fig. 2 A typical dialogue during the diagnosis of a Direct Translation type of misconception. An excerpt from the knowledge network related to the dialogue is also included.

The French "comme", which is interfering with the Italian "come", is not bound in any way to the concept (SI), but instead can be used correctly as a translation of "come" in (CP)⁵ contexts.

This interference can be at the origin of the misconception consisting of the conviction that, although (SI) and (CP) contexts are clearly distinguishable in Italian, also because there is a specific Italian conjunction "non appena" for (SI), which was not true for the disambiguation of (II2) and (CR) in the example of Fig. 1, the Italian student consistently translates "come" with "comme" irrespective of the context.

The answer to E1 of type (come, (SI)) is S1: "comme" which is expected wrong. ELISA puts a question E2 of type (non appena, (SI)) which is correctly answered by S2: "dès que". Finally, ELISA puts a question E3 of type (come, (CP)) and gets as answer "comme" which is again correct.

It can be concluded that:

- a. it is possible, but not certain, that the student distinguishes between (SI) and (CP) contexts. Since "non appena" and "dès que" are both unambiguously bound to (SI), the answer S2 does not show that the student recognizes the context (SI); (s)he might instead associate directly the conjunction "non appena" with "dès que" without being aware of the conceptual meaning of the context;
- b. the last hypothesis has to be considered confirmed by the behaviour of the student shown by S1 and S3: (s)he binds "come" to "comme" irrespective of the contexts, probably because of the interference between the two conjunctions. We call this misconception **Direct Translation**.

IV CONCLUSIONS

ELISA was a testbed for Intelligent Teaching

Systems in foreign language teaching, designed and developed in DART on the PLATO system for large scale use. Its paradigm can be utilized for teaching to translate any word or structure whose meaning depends on the context.

The full knowledge of ELISA concerning Italian and French conjunctions has been produced and an analysis has been made of the possible patterns of wrong behaviour. This analysis has led to the design of a strategy for the diagnosis of misconceptions underlying the surface mistakes, which has been (theoretically) tested in simple cases.

Because the real correct knowledge is extremely complex, and so the possible incorrect one, we expect to introduce heuristics into our exhaustive diagnostic strategy once it will be used in an experimental educational setting.

In particular, three aspects could be the object of empirical research on the protocols of interaction with ELISA, n1:

- a. the plausibility of the expected misconceptions, their frequency and the explanations - given by the students - of the causes of their wrong behaviour;
- b. the heuristics to be inserted in ELISA in order to induce the misconception from the diagnostic dialogue, e.g. taking the history of the whole teaching dialogue into account;
- c. the remedial procedure to be applied once the misconception has been classified (e.g. a "socratic" method).

Theoretically, ELISA's Italian-French knowledge network is a contrastive representation of the use of conjunctions and can be utilized in teaching independently on the computer program.

A representation of the syntax and the semantics of the contexts for their automatic production would certainly be the natural extension of ELISA's research within a project of automatic translation, and for a better understanding and explanation of the student's misconceptions as well.

Because the "a posteriori" linguistic definition of the "concepts" in the knowledge network can be considered an interlingua for the translation of conjunctions, one could conceive that an extension of the network of ELISA to more languages, constructed pragmatically from the contexts, although requiring a reorganization of the conceptual structure of the network, could be of some interest for any project of multilingual automatic translation.

ACKNOWLEDGEMENTS

We wish to thank J. Breuker, B. Camstra, M. van Dijk and P. Mattijsen for their contributions to the DART-ELISA project and R. Ambrosini and G.

⁵ (CP) means: 'Comparative Process'.

Fasano for their kind assistance in making the work concretely useful to the students. We also wish to thank Mrs. P.L. Tao per her correction of the English of this paper.

REFERENCES

- Brown, J.S. and Van Lehn, K. 1980 "Repair Theory: a Generative Theory of Bugs in Procedural Skills", Cognitive Science, 4: 379-426.
- Breuker, J. and Cerri, S.A. 1982, "A New Generation of Teaching Machines: Intelligent and Rather Intelligent Computer Assisted Instruction discussed and exemplified", in van Hees and Dirkzwager, (Ed.) Onderwijs en de nieuwe media; Swets and Zeitlinger, Lisse; 103-112.
- Cerri, S.A. and Breuker, J. 1980, "A Rather Intelligent Language Teacher", Proc. AISB European Conference on Artificial Intelligence AISB-80, Amsterdam (July). In a revised version also in: Hart R.S. (Ed.), Studies in Language Learning: the PLATO System and language studies, Univ. of Illinois, 3,1: 182-192 (1981).
- Cerri, S.A. and Breuker, J. 1981, "'Intelligent' dialogues on PLATO", in Cappelli, A., (Ed.), Linguistica Computazionale 2: Research in Natural Language Processing in Italy, Giardini, Pisa: 111-127.
- Cerri, S.A. and Merger, M.F. 1982, "The Knowledge Base of an 'Intelligent' Automatic Tutor of French-Italian Conjunctions", Scientific Report S-82-16, Dipartimento di Informatica, Univ. of Pisa (December).
- Merger, M.F. and Cerri, S.A. 1983, "Didattica Automatica 'Intelligente' delle parole straniere: le congiunzioni italiane-francesi", Pacini, (Ed.), Pisa (in press).