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# Language Resources and Visual Communication in a Deaf-Centered Multimodal E-Learning Environment: Issues to be Addressed

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## Abstract

This paper examines some of the major problems linked to the task of designing appropriate multilingual e-learning environments for deaf learners (DL). Due to their hearing disability most DL experience dramatic difficulties in acquiring appropriate literacy skills. E-learning tools could in principle be very useful for facilitating access to web-based knowledge and promoting literacy development in DL. However, designing appropriate e-learning environments for DL is a complex task especially because of the different linguistic background and experience DL may have, and of the multimodal language resources that need to be provided and integrated (e.g. language produced in the visual-gestural or signed modality, in written texts, closed captioning for vocal language information). The purpose of this paper is twofold: (1) describe and discuss issues we believe need to be addressed, focusing on the limitations that appear to characterize several e-learning platforms that have been proposed for DL; (2) present and discuss ongoing research aimed at overcoming these limitations.

## 1. Introduction

It is widely known that all over the world deaf children and, later, adults, experience dramatic difficulties in achieving appropriate receptive and expressive skills not only in oral or vocal language (VL) but also in written language. The vast majority of deaf learners (DL) achieve literacy levels that are markedly below those proper of their hearing peers (see among others Caselli, Maragna & Volterra, 2006; Garcia & Derycke, 2010; Garcia & Perini, 2010). As a result, in their school years through adulthood, DL experience equally dramatic difficulties in accessing the vast body of knowledge, and the rich learning environments made available by advanced multimedia technologies, most notably e-learning environments. Appropriate written language skills are in fact unquestionably a pre-requisite for exploiting the possibilities arising from such multimedia and multimodal learning environments.

In Italy as all over the world<sup>1</sup> the situation of DL is especially complex due to the very different language background and experience deaf persons may have depending upon the language they use as their primary or preferred means of communication, or L1. It is in fact necessary to distinguish two groups: (1) those who use Italian Sign language (LIS), the visual-gestural,

face-to-face language of the Italian deaf community (LIS-L1); (2) those who prefer to use spoken and written Italian (Italian-L1). It is important to stress that, on the whole, *both groups of DL* experience severe difficulties in achieving appropriate literacy levels – though of course ‘exceptional learners’ who overcome these difficulties can be found within each group.

With respect to signers, the following must be noted. Since the modern study of signed languages (SL) began with Stokoe’s (1960) pioneering work on American Sign language (ASL), world-wide research has led to describe, and to recognize as full-fledged human natural languages, a very large number of national SL, including LIS and all the other major European signed languages. The use of SL for instructional purposes has been explicitly recommended by the European Parliament (see Resolution 17-6-1988, art. D).

Bilingual education programs that offer signed and oral/written language instruction to deaf students have been developed in several countries, including Italy where they have been applied for the most to Elementary school children. As reported by Caselli & al (2006), it is unquestionable that the use of a SL, even if limited to its usual, face-to-face- form, can play a very important role in fostering DL’s general linguistic competence.

The inclusion of SL within e-learning platforms designed for DL has come as a natural development of the advancement that have been made in our knowledge of SL and of deaf signers. However, as we point out in sections 2 to 4 below, many recent and current attempts to develop appropriate e-learning environments for DL

<sup>1</sup> For reasons linked to the demography of deafness and to the complex sociolinguistic and cultural properties of signed languages the observations we make here with respect to Italy can be easily extended across nations and cultures, with the necessary changes concerning the national signed and vocal/written languages.

exhibit, and/or implicate some major conceptual, methodological and practical limitations.

In section 5 we present and discuss ongoing research aimed at overcoming these limitations.

## 2. Some general problems concerning existing e-learning platforms for DL

For the purposes of this paper, we limit our attentions to e-learning platforms designed for young or adult DL. An overview of several such platforms reveals the following major limitations. First, the guidelines for developing the desired platforms are often just “sketched”, and provide fairly general suggestions concerning, for example: - the inclusion of SL videos with SL translations or explanations of the written texts found in a specific e-learning platform; - the development of automatic tools (i.e. avatars) for translating written texts into SL; - the use of cooperation tools such as video conferencing<sup>2</sup>. Second, many existing or planned platforms appear to be designed primarily for DL who know SL, but *seem to neglect the needs of DL who prefer to use VL*.

On the whole, there appears thus to be a general trend towards creating and including SL materials for implementing written text-based environments. The contents encoded in written language are made more accessible to (signing) DL via SL translations and explanations. Other examples are the platform created within the project DEAL<sup>3</sup> for teaching foreign vocal-written languages to DL, or the one designed by Drigas & Kouremenos (2005) for vocational and general educational training.

A fairly large body of work has been dedicated to the development of signing avatars to be added to the users’ interface, replacing SL materials presented by real signers (see for example Efthimiou & Fotinea, 2007; 2008; Karouzis, Caridakis, Fotinea & Efthimiou, 2007, or also the recent Italian project “ATLAS”<sup>4</sup>).

Many projects for realizing signing avatars exhibit however, in our view, a rather surprising limitation: they appear to have a *unidirectional, VL-centered perspective*. They start, for the most, from VL written texts and aim at producing avatars that can translate such written texts into individual signs and signed sequences. These project thus ignore or underestimate the problem of *translating from sign to vocal/written texts*. There are only few projects that explicitly aim at realizing signing avatars functioning in both directions, i.e. from sign to speech and/or also written texts, and from speech and written

<sup>2</sup> See for ex.: *Individuals who are Deaf or Hard of Hearing*, Center for Assistive Technology and Environmental Access (CATEA), [http://www.accesslearning.net/mod1/1\\_02.php](http://www.accesslearning.net/mod1/1_02.php); *IMS guidelines for Developing Accessible Learning Applications*, IMS Global Learning Consortium, <http://www.imsglobal.org/accessibility/accessiblevers/index.html>; *General guidelines for Inclusive Online Cultural Content*, Canadian Network for Inclusive Cultural Exchange, <http://cnice.uutoronto.ca/guidelines.php>

<sup>3</sup> <http://www.deal-leonardo.eu>

<sup>4</sup> <http://www.atlas.polito.it/>

texts to sign. One example is “Signspeak” (see also the project “Dicta sign”)<sup>5</sup>

## 3. SL communication and instructional materials: what models of SL to adopt?

Irrespective of whether real signers or signing avatars are used, one additional limitation of many current efforts towards integrating SL materials into e-learning platforms concerns a failure to recognize important differences between SL and vocal/written languages, and the problems posed by the dramatically insufficient reference tools, and overall linguistic descriptions, that are currently available for SL.

It must first be recalled that *all SL are languages without a written tradition*. More importantly from a research standpoint, and even though almost 50 years have passed since the modern study of SL has begun, researchers still have not found an agreement on: (a) what are the constituent elements of SL; (b) what graphic systems can be used for representing SL in written form and, on this basis, develop appropriate reference tools (e.g. dictionaries, grammars, usage-based corpora etc) that are unquestionably necessary for both the communities of signers, and the exploitation of SL for educational and instructional purposes (see Cuxac & Antinoro Pizzuto, 2010; Garcia, 2006; 2010; Garcia & Derycke, 2010).

It is not trivial to stress that, although our knowledge of SL has considerably advanced, we still do not have any monolingual dictionary or grammar, for any of the SL that has been to date investigated - not even for ASL.

In this context, one could expect that well-grounded proposals aimed at exploiting SL for instructional purposes would dedicate particular care in making explicit the models of SL elements and discourse they adopt. This appears especially necessary because, as recalled hereafter, there are at present two major classes of models for describing SL. In agreement with Cuxac & Sallandre (2007) we will refer to these models as “assimilationist” vs. “non assimilationist”: the first type of models highlight primarily the structural similarities between SL and VL, while the second ones underscore that, in addition to important similarities there are equally relevant differences between SL and VL.

Within the limits of the present context, we illustrate some of the crucial differences between these two types of models in relation to the problem of defining what are the constituent elements of SL.

In substantial agreement with early, very influential descriptions of ASL provided by Stokoe (1960) and subsequently Klima & Bellugi (1979), assimilationist models assume that SL constituents units are *essentially comparable to VL words*, and are *primarily sequentially organized in time*. These models are still largely prevailing in current research on SL and have been for the most acritically adopted in educational applications

<sup>5</sup> <http://www.signpeak.eu>; <http://www.dictasign.eu>

of different types, including e-learning platforms.

In contrast, non assimilationist models, based on extensive analyses of SL discourse, show that SL constituent elements cannot be easily assimilated to VL units. In addition to word-like elements, SL possess complex, highly iconic structures (HIS) that are simultaneously organized in a multilinear fashion that has no parallel in VL. The differences between word-like and non-word-like units are marked by non manual and manual articulators, most notably by modality-specific eye-gaze patterns: when producing word-like units, the signer's gaze is directed towards the interlocutor, whereas when producing HIS the signer's gaze is typically directed away from the interlocutor.

Figure 1 below provides just two illustrative examples of a word-like unit (1a) and a non-word-like HIS (1b) that are commonly found in SL discourse. The examples are taken from LIS discourse but a wealth of similar examples can be found in all SL (for relevant discussions, see especially Cuxac, 2000; Cuxac & Antinoro Pizzuto, 2010; Pizzuto, Pietrandrea & Simone, 2007; Garcia & Derycke; 2010).

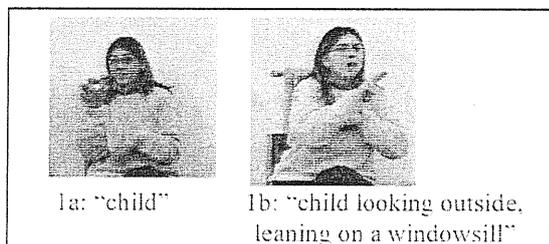


Figure 1: Word-like sign (1a) and HIS (1b)

The point we wish to stress here is the following: HIS are very frequent in SL discourse, ranging from 30% to as much as 90% (depending on discourse genre) of the constituent elements that can be identified and parsed in SL discourse (Boutet, Sallandre & Fusellier-Souza, 2010; Cuxac & Antinoro Pizzuto, 2010; Sallandre, 2003; Di Renzo & al, 2009). It should thus be evident that SL descriptions of any sort, including modelisations via signing avatars, cannot disregard as “marginal” these structures that appear unique of SL (see Cuxac & Dalle, 2007). E-learning materials based on the assumption that SL elements are for the most “just like VL words” thus exhibit severe limitations that need to be recognized, critically discussed and, hopefully, amended.

#### 4. Visual attention patterns in DL

An appropriate e-learning environment for DL at large, i.e. for both signers and non-signers, must take in due account a constraint that can be easily observed and yet, to our knowledge, has not been carefully investigated in previous research. When working with a computer, the visual attention patterns proper of DL markedly differ from those observable in hearing learners. This is true especially in situation of cooperative learning where the students must simultaneously attend to visual information concerning written materials of different

sorts to be “attended to” and processed, and other information stemming from the interaction with other fellow students and/or with a tutor (e.g. in exchanges taking place in actual classrooms or in videoconferences). Since deaf persons must use their sight, and accordingly orient their visual attention, to process both kinds of information, the two tasks cannot be carried out at the same time: DL cannot simultaneously look at teaching or explanatory materials displayed on the computer screen and at linguistic, interaction-based information given on the same materials which they must always decode primarily via vision (e.g. by lip-reading spoken utterances, processing a message in SL, reading subtitles).

This is much unlike what happens, in the same cooperative learning situation, for hearing learners who can simultaneously process communicative messages conveyed through sounds and freely orient their visual attention to other types of information coming from the computer screen. Devising an appropriate e-learning environment for DL thus requires accurate analyses of the ways in which these learners use and distribute their visual attention when performing different learning tasks, and how this can influence the learning process.

#### 5. Towards deaf-centered multilingual and multimodal e-learning platforms

Figure 2 schematically illustrates a model for an e-learning platform prototype (ELPP) prototype we are currently developing within the frame of a national project which pursues two major, interrelated objectives: (1) improving multilingual / multimodal e-learning environments for DL (High School and University students); (2) promoting their literacy skills<sup>6</sup>.

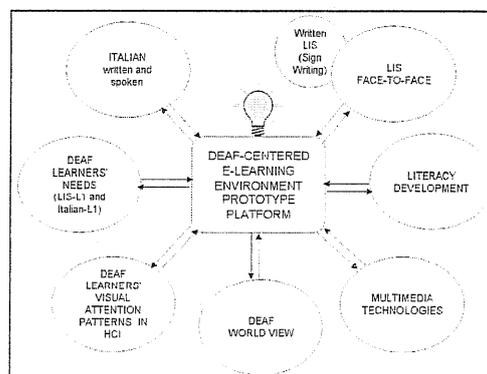


Figure 2: A model of deaf-centered e-learning platform

The ELLP model illustrated in Figure 2 aims at

<sup>6</sup> The project involves five research teams providing inter- and trans-disciplinary competences across the fields of: -SL linguistics; -special and bilingual education for DL; -multimedia tools for DL and hearing learners; -human-computer interaction and visual learning in e-learning environments; -foreign language teaching methodologies in both traditional and e-learning environments.

overcoming the limitations proper of many e-learning platforms (see discussion above) in different ways. Each of the major “conceptual components” of the model is at the same time *motivated by*, and *necessary for* designing a *deaf-centered e-learning platform*. The platform is grounded upon the idea that research aimed at creating useful products for deaf users needs to be developed, from the very start, *with* deaf persons, not just *for*, or *on* deaf people. Accordingly, and rather differently from what is reported for many past and ongoing projects directed to deaf persons, this idea guides our actual ‘project management’ practice. The project-leader team includes six deaf colleagues who *participate as protagonists in the planning and articulation of the entire research project*, not only as “end users” or “end evaluators” of the language resources and didactic tools to be produced or implemented. All our deaf colleagues are highly proficient in LIS: three learned to sign in infancy, within deaf signing families, three at different ages, as it happens to most deaf signers (see Cuxac & Antinoro Pizzuto, 2010); they possess different degrees of knowledge of spoken /written Italian which mirror in part their educational background<sup>7</sup>.

We give here just few practical examples of the crucial involvement of our deaf colleagues. The choice of the “contents” we will focus on for developing the ELPP<sup>8</sup>, and of the different forms in which such contents will eventually be presented to DL on the ELPP (e.g. spoken and written texts, speech-to-text captions, SL translations and explanations, graphic illustrations), was made following extensive discussions, among the deaf and the hearing members of the project, of different, alternative possibilities. Our deaf colleagues are contributing to the preparation of ad-hoc questionnaires and to a thorough examination and evaluation of language tasks, materials, multimedia technologies we are using and/or are currently developing (including for ex. the ELPP interface). In short, the active involvement of deaf colleagues ensures that the end products of our project be, on one hand, consistent with the “*deaf world view*”, (see Figure 2) – i.e. a complex configuration of experiential and conceptual knowledge that is strongly grounded in *vision* (see among others Lane, Hoffmeister & Bahan, 1996), and, on the other hand, effectively respond to *DL needs* (see Figure 2).

One other important element of the deaf-hearing collaboration we are promoting within the project is the following: all the hearing members of the project-leader team possess a good or advanced knowledge of LIS; four of the five (hearing) young researchers of the other research teams involved in the project are currently attending classes to learn LIS. We are also seeking

further collaborations with deaf experts who use Italian (rather than LIS) as their preferred language.

As noted above, most e-learning platforms for DL appear to be *designed only for signing DL*. In contrast, as shown in Figure 2, our ELPP aims at *addressing the needs of both signing (LIS-L1) and non signing (Italian-L1) DL*. In fact, as also noted above, both such groups of DL experience dramatic difficulties in *literacy development*. Our research aims at ascertaining the specific communicative-linguistic needs of each group of DL and the extent to which these are, or are not comparable. We expect that the results of our investigations will provide: (a) novel, relevant information on the linguistic-cognitive profile of the two groups of DL, clarifying also whether, and/or how knowledge of LIS as L1 may, or may not, interfere with the acquisition and use of spoken/written Italian; (b) important indications on how we may need to differentiate the multilingual and multimodal materials to be created for promoting literacy development in DL with LIS-L1 as compared to DL with Italian-L1. For example, recalling what noted in section 3, it would be plausible to hypothesize that, for DL with LIS-L1, the simultaneously organized, multilinear linguistic structures that are highly specific of their SL, namely HIS, may negatively interfere with the learning of more sequentially organized linguistic structures that are proper of written language. It would be equally plausible to hypothesize that these potential negative interferences should be absent in DL with Italian-L1. However, these hypotheses can be evaluated only by comparing the linguistic-cognitive profiles of the two groups of DL, as we plan to do in our project.

A substantial novelty of the multilingual / multimodal ELPP e-learning environment we are designing concerns the use, presentation (hence, by the same token, explicit modeling and representation) of the two major types of *language resources* that will be employed for pedagogical purposes, namely: Italian and LIS. What is novel in our model is that, as illustrated in Figure 2, written texts will be provided not only in *written Italian* (the target language in which we aim to promote DL literacy development), but also in *written LIS* – a language resource which, to our knowledge, has never been experimented in e-learning platforms for DL. *Spoken Italian* and *face-to-face LIS* (the latter in the form of digital videos) will also be used (see Figure 2).

For the instructional materials to be provided in *written Italian*, guided easification procedures will be used to facilitate DL’s access to textual materials; speech-to-text captioning tools will grant visual accessibility to materials given in *spoken Italian*; linguistic accessibility to the contents and forms of Italian-encoded instructional materials will be enhanced, for DL with LIS-L1, via appropriate videos providing translations and explanations in (face-to-face) LIS. Due to space limits, no further details are given here on these three types of language resources, which will be implemented drawing on a consolidated experience in

<sup>7</sup> Spoken/written language proficiency in deaf persons is highly variable and only partially linked to the educational level achieved. Our deaf colleagues include one doctoral student, one college graduate, one University student, three high school graduates.

<sup>8</sup> For space limits we can only mention here the ‘general contents’ of the ELPP: we will focus on the history, evolution and use of writing, and compare oral/signed vs. graphic/written forms of communication.

bilingual education for DL (Caselli & al, 2006), and more generally in language teaching methodologies, as detailed in our grant proposal. We describe briefly the rationale, empirical grounds, and major aims of our novel experimentation of written LIS.

As noted in section 3, all SL are at present without a written tradition. For DL with LIS-L1, the lack of a written form of their own SL may well be one of the obstacles on the road towards achieving appropriate literacy skills in a language – like Italian - that not only does have a written tradition but is also typologically very different from their own (see especially our remarks above on SL HIS). Recent research shows that Italian signers can profitably use Sign Writing (SW), a graphic system proposed by Sutton (1999) for writing SL, for: -transcribing LIS face-to-face productions; - creating, for the first time in the history of this SL, texts conceived directly in written LIS (SW has been adapted for these purposes to LIS). More importantly for the present discussion, this research shows that, relying on SW-encoded LIS texts, signers can autonomously perform meaningful comparisons between LIS and spoken/written Italian, at all structural levels - lexical, morphological, syntactic, textual, pragmatic.

On this basis, signers can formulate metacognitive and metalinguistic reflections on the structure of LIS as compared to spoken/written Italian, and more generally on the relations between “orality” or face-to-face vs. written communication, in a way that has never been possible, for them, without relying on a written representation of their SL (see among others Di Renzo & al, 2006; 2009; Gianfreda & al, 2009; Pizzuto & al 2006; Antinoro Pizzuto & al, 2008). Taking in due account the crucial role that metacognitive and metalinguistic skills notoriously play in the development of literacy skills, these research findings have motivated us to further experiment written LIS, on our ELPP, as a potentially very powerful pedagogical tool for promoting literacy abilities. SW-encoded, written representations of LIS have also proven to be extremely useful for advancing in the linguistic analysis of the language (Antinoro Pizzuto & al, 2008), paving the way for more appropriate modelisations which may be used for both general descriptive purposes, and for implementing the use of LIS as a linguistic resource on e-learning platforms.

We noted in section 4 that *DL's visual attention patterns in HCI* may significantly differ from those of hearing learners. One other additional novelty of our project concerns the use of eye-tracking equipment for analyzing DL's visual attention patterns, and compare them with those of hearing learners', during learning tasks which demand the simultaneous processing of language resources along with visual information of different sorts. Preliminary results of a pilot study we have conducted indicate that, in processing multimodal / multilanguage materials, the gaze patterns of DL with LIS-L1 markedly differ from those of hearing learners (Capuano, Levialdi & Antinoro Pizzuto, submitted). We trust that the more extensive investigations on this topic

we plan to develop within our project will provide us much needed, novel information for a better understanding of how visual information needs to be spatially and temporally structured in e-learning environments for DL, as compared to hearing users. These analyses will also allow to us ascertain whether there are (or not) relevant differences between signing vs. non-signing deaf students, when these DL with different language background access and use visually grounded information, of both linguistic and non-linguistic type.

Finally, recalling the crucial importance of vision in the 'deaf world view', we think that web-based *multimedia technologies and learning tools* for a deaf-centered ELPP may be significantly improved implementing a visually-based graphic interface. Drawing on ongoing research on the topic (Capuano & al, submitted), we aim at designing an interface that DL can access and use easily and 'intuitively' because textual information (which is difficult for them) is significantly reduced, or even entirely replaced by mostly non-textual (iconic) information. This entails the need of creating a new, graphic way for browsing web pages, and interacting with the ELPP.

For the natural, deaf-peculiar visual way of grasping information to be exploited in our platform, we are going to use a new interaction paradigm based on the theories of *embodied cognition* and *storytelling* (Lakoff & Johnson, 1980; Johnson, 1987; Imaz & Benyon, 2007). Within this paradigm, the learning process can be metaphorically represented as a story that includes the user as the main character. Accordingly, the user 'lives' the learning process by physically experiencing it – in the virtual space of the ELPP – as a path with a starting place, a sequence of several learning steps, and a final goal. Such a metaphor seems to be a very intuitive way of representing the learning environment. Moreover, it seems to be an adequate interaction paradigm especially for deaf users, since it exploits the visual channel as the main source of information.

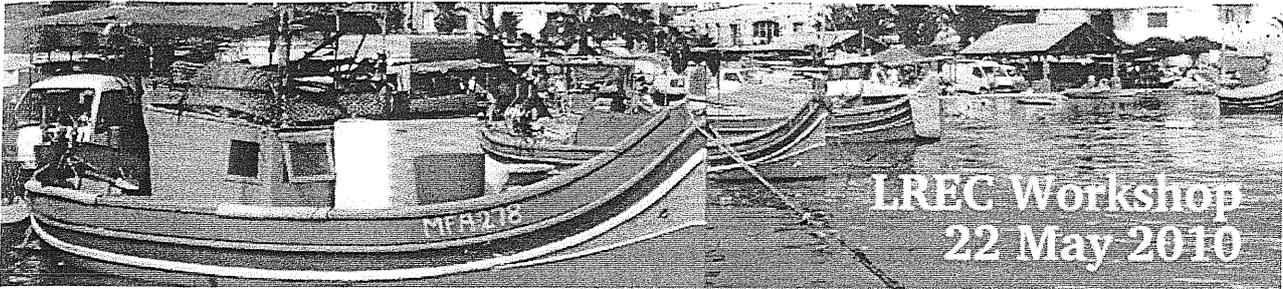
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