3D GREEK SIGN LANGUAGE CLASSIFIERS AS A LEARNING OBJECT IN THE SL-REDU ONLINE EDUCATION PLATFORM

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Abstract

Greek Sign Language (GSL), as well as most researched Sign Languages (SLs), possess a unique typological class of classifiers with distinct syntactic and semantic properties [1], [2], [3]. SL classifiers mark a predicate for specific geometrical properties as well as for position, movement and number, and they make obligatory use of the three-dimensional (3D) signing space [4], [5], [6]. Their distribution across different linguistic levels in GSL is high and they constitute a critical subject in GSL learning as a second language (L2). On the contrary, spoken language classifiers consist of linear sequences of words and do not carry a role as central as that of SL classifiers, while there is no evidence for any classifier structures in Indo-european spoken languages or in spoken Greek. Moreover, applied linguistics and teaching methodologies on 3D GSL phenomena such as classifiers require use of state-of-the-art technological applications on dynamic SL representation [7], [8], [9]. However, most GSL online curricula have yet not included classifiers in teaching and learning and still focus on lexeme sequences similar to those of spoken languages with established written forms, not taking advantage of the full potential of SL technologies. As a result, GSL classifiers are a challenging area for L2 learners to acquire and produce, while they are also a challenge for an online curriculum of GSL as an L2 [10], [11].

In the present paper we describe the SL-ReDu model and related educational content for teaching classifiers. SL-ReDu is an innovative interdisciplinary project exploiting technological advances in automatic SL recognition and language education methodologies for GSL teaching using L2 principles. SL-ReDu incorporates SL technologies of video recognition and automatic translation into a platform for teaching areas of GSL structure unique to SLs such as classifiers and addresses the needs of the students attending the GSL foundation course at ‘true beginner’s’ level (A0-A1) at the University of Thessaly, Greece [12]. In this manner any number of students can use their personal computer and web camera to produce classifiers and receive automatic feedback on their output, without the need of any additional equipment or software. Thus, the SL-ReDu platform is fully compliant with online L2 learning and compatible with 3D classifier presentation, comprehension, production and testing activities irrespective of the number of students attending, number of tutors involved or hours demanded for study.

Keywords: sign language learning, second language learning, self-assessment, online testing, sign language recognition, classifiers.

1 INTRODUCTION

Emerging technologies have a significant impact on all aspects of online learning. In the present paper we will discuss the application of selected features and capabilities on teaching and assessment of Greek Sign Language (GSL) as a second language (L2) through the educational platform of the SL-ReDu project. SL-ReDu is an innovative interdisciplinary project exploiting technological advances in automatic video recognition, automatic translation, and language education methodologies for sign language teaching as L2 in tertiary education.

While the incorporation of innovative technologies in natural language teaching and learning might be considered / viewed as a risk, at the expense of natural communication, we will attempt to demonstrate how learning and producing three-dimensional categories such as Classifiers in GSL as a second language cannot take place without technology enhanced learning. The SL-ReDu model exploits L2 methodologies or technologies currently available and incorporates these into the curriculum of the threshold level of a GSL course at the University of Thessaly (UTH) in a distance education method.
1.1 Three-dimensional SL Structures and Functions

SLs are natural languages in all respects [13], [14], [15]. However, the motor-visual linguistic modality, or channel, of production and comprehension allows for three-dimensional structures and typological categories that attribute specific linguistic value to shapes, position and movement, in contrast to the linear only, aural-oral modality of spoken languages in their oral or written form. Classifiers, central to SL structure, are perhaps the most distinguished/principal three-dimensional linguistic category of SLs [16], [17], [18].

Linguistic studies on classifiers in spoken languages describe these as morphemes marking for salient perceived or imputed ontological features of the nouns they attach to [19], 20]. In Indonesian, for example, certain classifiers are used as quantifiers for number marking, for shape such as ‘small object’ (biji) ‘long, cylindrical object’ (batang) or for [+animate] (orang) marking [3].

GSL, on par with most researched SLs, possesses a unique typological class of classifiers with distinct syntactic and semantic properties. GSL classifiers mark a predicate for specific geometrical properties as well as for position, movement and number, and they make obligatory use of the three-dimensional (3D) signing space. Their distribution across different linguistic levels in GSL is high and they constitute a critical subject in GSL learning as L2. On the contrary, spoken language classifiers consist of linear sequences of words and do not carry a role as central as that of SL classifiers, while there is no evidence for any classifier structures in Indo-European spoken languages or in spoken Greek.

1 Indicative examples of spoken Indonesian classifiers [3].

<table>
<thead>
<tr>
<th></th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>1a</td>
<td>dua orang mahaguru</td>
</tr>
<tr>
<td></td>
<td>“two lecturers”</td>
</tr>
<tr>
<td>1b</td>
<td>dua biji bola</td>
</tr>
<tr>
<td></td>
<td>“two balls”</td>
</tr>
<tr>
<td>1c</td>
<td>dua batang pollot</td>
</tr>
<tr>
<td></td>
<td>“two pencils”</td>
</tr>
</tbody>
</table>

The study of SL classifiers is much younger than that of their spoken equivalents; SL descriptive linguistics took shape as a scientific field of its own right only in the 1970s. Almost all of the researched SLs up to date demonstrate classifier constructions. The typological features of these classifiers correspond to verbal classifiers while there is strong evidence for SL classifier functions as linking elements between parts of a sentence [1], [6]. On the other hand, there have been some claims on the fluctuant and the partly non-predictable or measurable patterns of movement and position of SL classifiers (see for example, [14], [3], and [2]). Similar claims are led by the partly transparent ontological characteristics of SL classifiers, which do represent physical properties of real world objects, albeit within a linguistic system, while neurolinguistics studies show that they are processed not only through centers of the brain responsible for language but using spatial and movement perception neural mechanisms. Striking as this may be for traditional linguistics, it is a fact that SLs are incomplete without classifier constructions, whether these belong to the core or to grey areas of SL systems.

The handshape of a classifier carries the general nominal semantic information, while position and movement mark for grammatical information. SL classifiers are usually combined with verbs of movement, position or change of position and retain the same handshape across longer parts of a sentence or of multiple sentences, referring to a specific nominal. For example, describing a vehicle movement in GSL, a classifier handshape appropriate for the nouns car, bus, train etc follows the noun, while the position and movement of the classifier provide information about the manner, length, route etc of the nominal (vehicle). In their double-handed forms, they also mark for dual.

2 Indicative functions of GSL classifiers for marking position and orientation of an animate semantic entity, as well as of a two-dimensional and a three-dimensional entity.

<table>
<thead>
<tr>
<th></th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>2a</td>
<td>FEMALE CL2handed [+animate] standing position</td>
</tr>
<tr>
<td></td>
<td>“two female persons are standing (indicating exact position and orientation of persons).”</td>
</tr>
<tr>
<td>2b</td>
<td>BALL CL [sphere] falling</td>
</tr>
<tr>
<td></td>
<td>A ball is falling (indicating exact position and orientation of the ball, as well as manner of movement).</td>
</tr>
<tr>
<td>2c</td>
<td>TABLE PENCIL CL [2dimensional] laying horizontally</td>
</tr>
<tr>
<td></td>
<td>A pencil is on the table (indicating exact position and orientation of the pencil).</td>
</tr>
</tbody>
</table>

3 Indicative examples of GSL semantic entity, +animate classifiers (Dicta Sign REF)

<table>
<thead>
<tr>
<th></th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>3a</td>
<td>FEMALE RUN CL [+animate]</td>
</tr>
<tr>
<td></td>
<td>“A female person is running”</td>
</tr>
</tbody>
</table>
In conclusion, research on SL Cl semantics and morpho-phonology now allows for developing descriptive and educational applications for GSL learning, teaching and assessment as a first or as a second language (L2).

In practice, however, applied linguistic research on SL corpora and SL-L2 curriculum design have largely omitted teaching of Cls mainly due to the need of critical adaptations in methodology in order to present and teach three-dimensional SL structures. Instead, the influence of mainstream spoken language linguistics is prominent in SL curricula, focusing on isolated lexical signs and linear sign sequences similar to those of spoken languages (see, for example, [21], [22], [23], [24], [25]. This trend might also be partly due to the fact that classifiers are attested in some spoken languages, but neither Greek nor any Indo European speaking learners are familiar with a similar structure or function. As a result, there is evidence for low output quality of classifiers by SL and GSL-L2 signers overall. However, the growing spectre of technologies available during the last two decades provides a variety of options among appropriate tools for a precise description and transmission of SL classifiers. The SL-ReDu platform exploits and applies updated SL linguistic findings with state-of-the-art technological advances.

1.2 Applied and Online Teaching of GSL Cls

Non-native users of GSL as an L2 are a disproportionately large population consisting of professionals in areas related to deafness, family and people close to deaf and hard-of-hearing people’s life as well as late deafened individuals. As a result GSL is a foreign or second language for the majority of its users, deaf or hearing. The first GSL educational corpora and curricula appeared in the 1990s while research on online GSL transmission and automatic translation evolved mainly after the Millennium. Distance education in general and distance L2 learning, in particular, are nowadays widespread especially after the 2020 pandemic following an increasing demand that can now be met through the public availability of necessary technology. In the area of GSL learning as an L2, three-dimensional phenomena as well as use of video in all aspects of learning and teaching complicates the setup and functions of educational applications, especially on GSL students’ Cl production and assessment using video.

The SL-ReDu platform is the output of a coordinated interdisciplinary effort that applies recent linguistic findings, aims to cover actual course content, while it develops state-of-the-art technologies; SL technologies of video transmission as well as video recognition and automatic translation are incorporated into a platform for teaching classifiers. The educational content of Cls covers the needs of the students attending the GSL foundation course at ‘true beginner’ s level (A0-A1) at the University of Thessaly, Greece, and expands beyond it. It aims to familiarize students with the GSL non-linear linguistic representations in the visual-motor modality, not attributing spoken or written word equivalents to each concept but rather group concepts by shape, position and orientation properties. Grammatical information such as plural and quantifiers in GSL can also be marked by Cls along with spatial characteristics. These are also subtly introduced to GSL-L2 M2 users of the platform, allowing the students to smoothly proceed to the next learning levels during their second or third semester of study at the university.

2 METHODOLOGY

Introducing Cls to beginner GSL students in the SL-ReDu platform addresses a crucial gap in SL teaching practice in the area of self-assessed accuracy of linguistic productions. Throughout the Cl content of SL-ReDu, the self-monitoring units of listening and reading, as well as writing and speaking, are respectively replaced by their visual counterparts of viewing and perceiving Cl signing. Any number of students can use their personal computer and web camera to be introduced to a course chapter, perceive or produce classifiers and receive automatic feedback on their output, without the need of any additional equipment or software. The material is organized in sections, each of which is preceded by an example or an explanation, followed by exercises of various types that the learner navigates at a leisure pace.
In this method, students can organize visual perceptions of object classes according to GSL semantics and they can actively sign any given CI in order to enhance and solidify new knowledge. Muscular memory of movement through repetition and correction is a process crucial throughout the process of SL learning and has required the physical presence of a native signer as an evaluator among other challenging SL learning and assessment issues [26], [23].

3 RESULTS

3.1 Classifier Content Organization

Particularly for GSL, a significant amount of annotated lexical and corpus data are available at Athena-RC / ILSP, including the Dicta-Sign corpus [27], the DIANOEMA dataset and the POLYTROPON parallel corpus [28]. Additional GSL data have also been recently collected by the Special Education Department at the University of Thessaly. The SL-ReDu CI corpus on the platform consists of single handed or double handed symmetrical classifiers, following a functional adaptation of the Supalla model of classification. Among several classification models that have been proposed and revised for SL classifiers, the Supalla ([1], revisited in 1990) model is the most widely used in classifier research, dividing the category of CIs into Semantic classifiers, Shape and Size classifiers (static or outline), and Handling classifiers. The first two of these categories, as well as a subset of handling classifiers, tool classifiers, have been incorporated in the SL-ReDu for educational reasons. These subsets are more straightforward to perceive and produce at the early learning stages of the SL-ReDu target users, also being those of the highest frequency of occurrence, accounting for a total of 87.5% of the GSL classifier corpus SL-ReDu is based on (Dicta Sign REF). Double handed non symmetrical CIs are not included in the SL-ReDu CI curriculum, as they are a lot sparser in distribution (12.63% of total CI occurrences) as well as significantly harder for students to perceive at GSL L2 early stages. Each category is presented in most frequent orientation and position forms (Fig. 9, 10 & 11). Inclusion of the majority of forms of the most frequently used CIs in the SL-ReDu platform content even at the earliest learning stages allows students to approach GSL through the visual-motor modality, apply three-dimensional structures to their signing from the beginning and avoid common language transfer phenomena between spoken Greek and GSL, which hinder progress in GSL as L2 in the long term [11].

Table 1. Subsets of classifiers per frequency of occurrence in the Dicta Sign GSL corpus.

<table>
<thead>
<tr>
<th>Classifiers</th>
<th>N</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Semantic entity</td>
<td>477</td>
<td>36%</td>
</tr>
<tr>
<td>SASS Outline</td>
<td>233</td>
<td>17.62%</td>
</tr>
<tr>
<td>Handling</td>
<td>200</td>
<td>15.3%</td>
</tr>
<tr>
<td>Lexicalized</td>
<td>130</td>
<td>9.8%</td>
</tr>
<tr>
<td>SASS Static</td>
<td>129</td>
<td>9.7%</td>
</tr>
<tr>
<td>Predicative</td>
<td>75</td>
<td>5.67%</td>
</tr>
<tr>
<td>Other</td>
<td>67</td>
<td>5.06%</td>
</tr>
<tr>
<td>Bodypart</td>
<td>14</td>
<td>1.05%</td>
</tr>
</tbody>
</table>
Semantic entity classifiers content in the platform includes categories for the following:

- **Human**
- **Vehicle**
- **Single-point (no dimension) object**
- **One-dimensional object**
  - **Two-dimensional object**
  - **Three-dimensional object**
  - **Outline classifier**
  - **Small-entity classifier**

Semantic entity classifiers are the most frequent Ci subset (36%), followed by SASS Outline and Static CIs (27.38%) in the Dicta-Sign corpus on GSL (REF). They refer to animate or inanimate entities and are usually formed using the following handshapes (Fig. 3-7).

![Figure 3. CL-D: single-point](image1)
![Figure 4. CL-4: single-point plural](image2)
![Figure 5. CL-5C: 3D](image3)

![Figure 6. CL-5: 2D, no borders](image4)
![Figure 7. CL-B: 2D, borders defined](image5)

![Figure 8. standing face away from signer](image6)
![Figure 9. lying face-up](image7)
![Figure 10. sitting](image8)

Animate entity CIs are presented and explained in detail in a subcategory of their own in the SL-ReDu platform, as they allow the student to perceive and produce virtually any type of human movement in signing space. They are formed with CL-H and CL-HC handshapes in specific orientation variations such as those illustrated in Fig. 8, 9 & 10.

Static and outline SASS classifiers refer to the shape of objects that GSL marks, the latter using movement to describe the outline and shape of the referent. Each of SASS CI subsets is presented in the SL-ReDu platform as a separate chapter in the curriculum. The most usual geometrical shapes marked for in GSL are: flat-and-wide (using handshape CL-B and CL-5), long-and-thin (CL-D), spherical or cylindrical (CL-C2, CL-C and CL-5C) or small-and-round-shaped (CL-F) respectively.
3.2 Platform Layout

The platform layout is plain for optimal concentration on the visual learning material. Use of text is minimal. Audio is not included in any stage of the learning process while overall the cues are based on visual graphics of image or video.

![Image of platform layout]

Written linguistic input or prompts do not appear throughout CI units; classifiers are presented aligned to groups of physical entities with specific shared properties. Initially, students can observe the shared properties for each classifier group and then practice their understanding in passive (Fig. 12) and active (Fig. 1) exercises. In passive exercises input is either images or video that has to be matched with the corresponding classifier. In active exercises students view a set of images and/or video and are prompted to submit the correct response on camera. Activities are split in two levels, short and straightforward series of exercises for absolute beginners, as well as combinations across unit CI content for students who have progressed towards becoming accustomed to GSL perception in mental images.

4 CONCLUSIONS

Three-dimensional linguistic phenomena such as CIs are unique to SLs and challenging for L2-M2 students. Teaching CIs online is an even harder challenge. The SL-ReDu platform has incorporated GSL CIs using fully compliant methodology to online L2 learning, respecting the three-dimensional nature of GSL and covering all presentation, comprehension, production and testing activities necessary, irrespective of the number of students attending, number of tutors involved or hours demanded for study while it provides easy-to-use tools for the students to submit responses signing in front of an ordinary web camera. From a theoretical linguistic point of view, the SL-ReDu CI curriculum for the first time provides the tools necessary for GSL L2-M2 students to classify linguistic entities on the basis of their geometrical properties, thus changing their linguistic viewpoint of Language in general. The significance of the SL-ReDu classifier content lays on its contribution to applied linguistics of sign languages (SL) and online SL curriculum design.

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