The Development of a Medical Dataset in Italian Sign Language (LIS): Theoretical Considerations and Practical Applications

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Automatic translation to and from Italian Sign Language (LIS) requires the development of computational models, such as avatars, capable of accurately reproducing both manual and non-manual articulators of signed discourse. This, in turn, demands the creation of machine-processable and linguistically robust data collections, built through the segmentation, transcription and systematic categorization of signs, to capture their internal structure and relational dynamics. Such a framework should reflect the multilinear organization of LIS, which poses several challenges. These include the visual-gestural and simultaneous nature of LIS, the absence of a standardized written form and the scarcity of available resources. Key challenges arise at multiple levels, including the very development of LIS resources, the identification of suitable tools for capturing signed data and the lack of a standardized coding system for signed languages. These aspects were addressed in the development of the MultiMedaLIS Dataset (MULTImodal MEDicAl LIS Dataset), a preliminary dataset in the medical domain, collected using multimodal capturing tools. Annotation, performed using ELAN, followed the principles of simplicity and readability by employing multilayered labelling in both Italian and English, along with a dedicated annotation system for signed languages. In this way, the Dataset is accessible to both signers and non-signers, currently serving as a resource for linguistic analyses, as well as for training algorithms for automatic sign recognition.

1. Introduction

Constructing accessibility through the interaction between natural language processing (NLP) technologies and Italian Sign Language (LIS) requires careful epistemological reflection. This involves not only acknowledging the linguistic specificities of LIS, but also considering the perspectives of the signing community and the language's everyday use. Language, in fact, is not an entity detached from its context of use, as every linguistic feature emerges from the interplay of social, cultural and linguistic factors. Social variables are thus integral to the functioning of language and cannot be treated as external or secondary elements. Adopting a multimodal approach to sign language analysis, as this study intends, involves understanding language as a fundamentally face-to-face phenomenon, inseparable from the sociocultural context in which it occurs. Therefore, both linguistic and social dimensions must be taken into account when developing and processing sign language data. Furthermore, the application of computational processing techniques to LIS data presents specific challenges that must be addressed to ensure that the proposed solutions are effective and accurate.

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Moving from these statements, this paper is structured as follows. First, it provides an overview of the current state of the art regarding LIS corpora and datasets, followed by a discussion on the usability of datasets that include isolated signs. The third section addresses the tools most suitable for capturing signed data, comparing previous multimodal collections involving both LIS and Italian, and outlining key principles for selecting appropriate recording tools. The fourth section discusses the methodological and ethical challenges of working with an oral, under-documented and minority language, taking into consideration its visual-manual modality, the complexities of its annotation, existing and possible future annotation strategies, and the central role of deaf individuals in sign language research. Lastly, the MultiMedaLIS Dataset is introduced from a theoretical perspective, discussing the motivations behind its theorization, development, collection and partial annotation, along with its broader sociological framing.

2. State of the Art for LIS Corpora and Datasets

The availability of language datasets is a requirement for NLP, providing the empirical foundation for developing and evaluating models across a range of language-related tasks, including machine translation. However, for under-documented or minority languages, the scarcity of such resources presents meaningful challenges[1]. LIS is among the languages that currently lack comprehensive and publicly accessible datasets, an absence that contributes to significantly slowing down both research and technological advancements.

Existing sign language collections can be broadly categorized into corpora and datasets. The distinction between the two lies primarily in the nature of the linguistic material, as well as its intended purpose[2]. Corpora are structured collections of (semi-)spontaneous signing, produced by native or near-native signers in natural communicative contexts to capture and represent authentic language. Although sign language corpora can be frequently recorded in controlled studio environments, using multiple cameras and consistent lighting conditions (Crasborn and Zwitserlood 2008; Hanke and Fenlon 2022), there are also instances of corpora collected in more naturalistic settings, such as local deaf association venues, which aim to capture signing as it occurs in everyday contexts (Geraci et al. 2011). To qualify as a corpus, a collection should include at least five hours of signed recordings (Kopf, Schulder, and Hanke 2022), and should be annotated with translations and/or glosses, henceforth referred to as Vocal Language Labels (VLLs)[3] (Antinoro Pizzuto, Chiari, and Rossini 2008). Furthermore, they should

1 Among the largest sign language corpora currently available are the BeCoS Corpus (around 177 hours) (Vandeghinste et al. 2022), the Corpus Vlaamse Gebarentaal (around 140 hours) (Van Herreweghe et al. 2015), the DGS Corpus (German Sign Language, 330 signers) (Konrad et al. 2020), and the Corpus NGT (Dutch Sign Language, over 2300 sessions) (Crasborn and Zwitserlood 2008). Despite their value, these corpora remain orders of magnitude smaller and more limited in scope than most vocal language corpora, which often comprise millions or billions of words across diverse registers and genres.

2 For an updated collection of available resources, see https://www.clarin.eu/resource-families/sign-language-resources (accessed on July 20th, 2025).

3 In the field of sign language linguistics, glosses, also referred to as Vocal Language Labels (VLLs) (Antinoro Pizzuto, Chiari, and Rossini 2008), are transcriptions that represent signs using the written form of a spoken language. Each sign is typically rendered as one or more uppercase words. For example, *CAT* may be used to label a sign expressing the concept of 'cat'. In accordance with best practices in corpus annotation (Hodge and Crasborn 2022), this work adopts the explicit terminology VLL in place of the more general 'gloss', to make explicit the written nature of these labels and their reliance on the orthography of spoken languages. This choice also serves to highlight the contrast with sign languages,

also be ideally enriched with multi-layered linguistic annotations (Hodge and Crasborn 2022; Schembri and Cormier 2022; Fenlon and Hochgesang 2022). On the other hand, datasets, particularly those developed for machine learning applications, such as sign language recognition or translation, are often composed of elicited or scripted signing, recorded in constrained settings and sometimes produced by non-native signers or hearing interpreters. These datasets focus on consistency, annotation alignment, and multimodal compatibility (e.g., with skeletal tracking), rather than linguistic naturalness (De Sisto et al. 2022)[4].

In the context of LIS, the absence of accessible, large-scale collections has led researchers to create small-scale and purpose-specific ones, tailored to individual research needs. This situation reflects both the fragmented state of LIS documentation, as well as the methodological heterogeneity that characterizes data collection efforts, which vary depending on the intended application of the data. Collection methods range from naming tasks and semi-structured interviews with deaf participants to video-recorded sessions with hearing learners of LIS as a second language (L2) and/or second modality (M2). Alternative approaches, such as recordings in domestic settings (Geraci et al. 2011) or through online video calls (Gianfreda 2011), are also attested. Some projects have aimed primarily at language documentation involving deaf signers (Russo 2004; Gianfreda 2011; Geraci et al. 2011; Roccaforte 2016). These collections are generally not publicly accessible and remain scattered across individual researchers or institutions. Other initiatives have focused on documenting LIS acquisition by hearing learners, thereby contributing to the understanding of LIS as an L2 and L2M2 system (La Grassa 2016). Additionally, a large, though non-public, archive of LIS material exists in the form of videos produced by LIS interpreters for TG LIS, the signed news program of the Italian national broadcaster.

LIS data collection has also supported technological applications. This is the case for the LIS4ALL project (Geraci, Mazzei, and Angster 2014b, 2014a), whose development led to the creation of a dataset of 50 LIS utterances comprised of joined isolated signs (Mazzei 2015). The same infrastructure has also been employed for other applications, including RAI's Virtual LIS, a platform that uses 3D avatars to render LIS content for national television broadcasts.

In sum, LIS research has drawn on a range of fragmented and often inaccessible data sources. The absence of publicly available, large-scale collections remains a significant barrier to both empirical linguistic research and the development of data-driven applications. Existing resources differ substantially in terms of scope, annotation format and accessibility, and are frequently the outcome of *ad hoc* or project-specific initiatives. In this context, the development of smaller, semantically focused collections (often based on isolated or elicited signs) represents a pragmatic, albeit limited, contribution. These issues are not unique to LIS. Rather, they mirror systemic challenges in the development and processing of sign language resources more broadly. One of the most pressing limitations is the scarcity of large-scale, high-quality, and richly annotated corpora suitable

which are visual-manual and lack a widely adopted written form, thus emphasizing the asymmetry introduced by the use of vocal language writing systems in their annotation.

4 While the MultiMedaLIS Dataset (see section 5) includes some features typically found in corpora (VLL, translations, multi-layered annotations) (De Sisto et al. 2022), it also shares key characteristics with lexical resources and datasets developed for machine learning. It contains isolated signs, produced by a non-native signer, and includes over 100 entries, which match criteria for lexical resources (Kopf, Schulder, and Hanke 2022). Moreover, the non-spontaneous nature of the data and its potential use in sign language recognition or translation align with the type of datasets described by De Sisto et al. (2022).

for training data-intensive models in sign language recognition (SLR) and translation (SLT) (Vandeghinste et al. 2023).

Another persistent obstacle is the lack of standardization in annotation schemas and labelling conventions. Despite the widespread use of tools like ELAN, signed language collections diverge significantly in tier structures, segmentation strategies, and the linguistic granularity of VLLs. This variability greatly limits compatibility across resources and obstructs the progress of multilingual or cross-linguistic models. The issue is further complicated by the lack of common annotation guidelines, especially concerning classifier structures and pointing signs/Deictic Units[5].

An additional layer of complexity in these technical challenges arises from the predominance of interpreted rather than naturally occurring final data. A significant portion of video content used for linguistic or educational purposes is crafted by hearing interpreters, which leads to "translationese" signing that diverges from native signing norms in terms of both structure and use (De Sisto et al. 2022). Though such data has its usefulness for select applications, it poses critical limitations when training models intended to generalize across naturalistic inputs.

Addressing these challenges will require sustained cross-disciplinary collaboration. Key priorities include the adoption of unified annotation standards, the development of preprocessing toolkits to facilitate dataset alignment and multimodal feature extraction, and a commitment to open-access principles where ethically and legally feasible (Fenlon and Hochgesang 2022; Vandeghinste et al. 2023). Only through such efforts can sign language research and technology development achieve the scalability, reproducibility, and inclusivity that have long characterized work in high-resource spoken languages.

2.1 Developing Isolated and Elicited Collections for LIS: a Partial Solution

Semantically restricted datasets of isolated signs represent a partial but practical response to the limitations mentioned above. Focusing on isolated signs originating within a limited and specialized semantic domain (e.g. medicine, law, economics) facilitates annotation and allows for clearer alignment with vocal language translations. Considering the context of under-documentation, these features are especially valuable for training automatic sign recognition models, which currently lack access to large, annotated data collections of LIS. Isolated signs also reduce the need for context-dependent interpretation, making them more manageable from both a linguistic and technical standpoint. A limited domain not only increases internal consistency, but also aligns data collection with high-impact areas, such as healthcare, where communication barriers are particularly felt (Mazzocca and Ottolini 2022). In this sense, semantically focused and isolated-sign datasets can serve as resources for targeted applications, while acknowledging the broader need for discourse-level corpora.

3. Which Tools to Use to Capture Signed Data? Insights from Multimodal Data Collections for LIS and Italian

Already several decades ago, Armstrong and colleagues observed that both vocal and signed languages (regardless of whether they are written) would eventually benefit not from improved writing or annotation systems, but from advances in methods for recording, analyzing and working with language data (Armstrong, Stokoe, and Wilcox

5 See section 4.1 (Volterra et al. 2022).

1995). This prediction has largely proven accurate. Nonetheless, sign language research still lags behind in this respect, particularly in the case of LIS. Building on the state of the art outlined above, the present work adopts a dual perspective: it aims to combine qualitative ethnolinguistic methodologies (Duranti 1997, 2007) with high-quality multimodal data collection techniques.

To contextualize the presented data collection methodology within the broader context of multimodal data collections in the Italian context, two prior models (Geraci et al. 2011; Lo Re 2022) were considered and partially adapted, with variations, with a particular focus on data collection tools. This led to the development of a multimodal dataset where the selection of the recording tools was characterized by the following principles:

- **Portability and non-invasiveness.** Data collection tools should be portable and minimally intrusive. Portability will allow to gather data across various settings and with different participant profiles, including contexts where access to specialized equipment is not feasible. Non-invasiveness avoids recording practices that risk altering the natural behavior of signers, such as the use of gloves or motion-capture suits, which not only might not capture facial expressions, but often fail to capture the full complexity and simultaneity of signed language parameters.
- **High-quality multimodal capture.** Tools should be capable of producing data suitable for detailed post-processing granting that visual, spatial and temporal features of signing are accurately preserved.
- **Balanced resolution and practicality.** While high-resolution recording is desirable, it must be balanced against the aforementioned priorities of portability and non-invasiveness, particularly when collecting data in non-studio environments.

This data collection strategy enables the development of a high-quality dataset that can be used for broader or more specific research, as well as to reach objectives such as automatic language processing. The goal is to demonstrate that, when contextualized within interdisciplinary frameworks that bring together linguistic, ethnographic, and computational methodologies, even targeted efforts may provide valuable outcomes.

4. Methodological and Ethical Challenges in Sign Language Research

Working with LIS (or any other sign language) involves managing a complex set of linguistic, technical and ethical challenges that shape the type of data that can be collected, the methodologies available for analysis and the broader implications of research practices. Developing robust approaches to LIS thus requires careful consideration of its modality, the current landscape of annotation practices and the ethical responsibilities that arise when working with a minority language (Fox, Woll, and Cormier 2023). Consequently, this section is organized around three topics. Firstly, it considers the visual-gestural and multimodal nature of LIS. Secondly, it addresses the methodological challenges of annotating LIS data, with particular attention to the absence of a standardized writing system and the limits and advantages of VLL-based transcriptions. Thirdly, it turns to the ethical dimensions of this work, discussing the importance of community involvement, epistemic justice and responsible data practices.

4.1 Visual-Gestural Articulation and Semantic Strategies

From an articulatory standpoint, the first consideration concerns the visual-gestural nature of LIS which, like all sign languages, is inherently multilinear and multimodal

(Cuxac and Antinoro Pizzuto 2010). In signing, meaning is constructed through the simultaneous use of the entire body, from the top of the head to the hips. Hands are not the sole articulators: facial expressions and bodily movements play a central role.

Traditionally, two categories of articulatory elements have been identified: manual and body (or non-manual) articulators. A sign may include elements from one or both categories. Manual articulators comprise hand configuration (i.e., the positioning of the fingers), palm orientation, location of articulation and movement. Body elements include facial expressions, torso movements, eye gaze direction and oral components (Volterra et al. 2022). The latter are further subdivided into mouthings, that is, articulatory features borrowed in whole or in part from vocal language and mouth gestures, which involve movements of the mouth that are not related to any vocal language (Fontana 2008).

Manual and body articulators interact to produce three primary mechanisms of meaning-making in sign languages: *pointing* (via Deictic Units), *telling* (via Lexical Units) and *showing* (via Transfer Units[6]) (Volterra et al. 2022). In addition to Lexical Units, also known as "frozen" signs, which are relatively standardized and more readily found in dictionaries, complex iconic structures can communicate through showing rather than telling. These Transfer Units are not fixed entries but are dynamically constructed and deeply rooted in iconicity. Body elements play a particularly important role in the articulation and interpretation of these forms. Among them, eye gaze is crucial for distinguishing between Lexical and Transfer Units. Specifically, when using Lexical Units, signers tend to direct their gaze toward the interlocutor, whereas in Transfer Units, the gaze typically shifts toward the hands, reinforcing the iconic and demonstrative nature of the sign (Cuxac and Antinoro Pizzuto 2010; Cuxac and Sallandre 2002, 2007; Bianchini 2021).

4.2 The Annotation Issue

Sign languages are oral languages in the sense that, like many vocal languages, they lack standardized and formal writing systems. Consequently, they are used exclusively in face-to-face communicative contexts, whether in-person or virtual (Volterra et al. 2022). This oral nature presents challenges for the systematic analysis and definition of the language, particularly when attempting to formalize its structures and phenomena (Fontana 2014).

The annotation issue has long been acknowledged within the LIS research community, though few substantial developments have emerged over time. Given the scope of the present study, this matter will be addressed exclusively within the context of computational applications. Broader ideological or societal debates, such as the appropriateness or desirability of one representation method over another, will not be discussed here, as they have already been extensively addressed (Antinoro Pizzuto, Rossini, and Russo 2006; Antinoro Pizzuto, Chiari, and Rossini 2008, 2010; Garcia and Sallandre 2013).

6 In this study, a cognitive and socio-semiotic framework (Volterra et al. 2022), which employs the terms "Lexical Units" and "Transfer Units", is adopted to categorize signs. This framework has also been used for annotating the Dataset discussed, thus motivating the choice to use this particular terminology. While these terms correspond to the more commonly known "Frozen Lexicon" and "Productive Lexicon" in the broader sign language literature (Vermeerbergen and Van Herreweghe 2018; Branchini and Mantovan 2022), adhering to Volterra et al.'s nomenclature is consistent with the annotation methodology and facilitates comparability within the same theoretical framework.

The lack of a standardized writing system, combined with the necessity for researchers to manually annotate sign language data in order to generate machine-readable inputs for algorithm training, represents one of the most significant challenges in applying NLP techniques to sign languages. This is not a marginal concern and cannot be disregarded. If a corpus is to be considered machine-readable, it must consist of well-organized data that can be easily searched and retrieved (McEnery and Wilson 1996; McEnery and Hardie 2011) and its annotations must be consistent and coherent (Hodge and Crasborn 2022). Consequently, data collection in sign language research must go hand in hand with the issue of annotation.

Deaf signers as bimodal bilinguals, that is, individuals who use two languages across different modalities, such as Italian (auditory-vocal) and LIS (visual-manual), live in a diglossic linguistic environment. In this context, a sign language coexists with the vocal (spoken and written) language of the hearing majority. Historically, this has led to a reliance on the written form of the dominant vocal language. For example, deaf individuals in Italy typically write in Italian. This sociolinguistic dynamic has influenced research practices, in particular in the widespread use of VLL which, as an external transcription method that relies on translation, fails to capture the full expressiveness of signed language. While VLLs may serve the practical purpose of rendering signed data machine-readable and are accessible to individuals familiar with written Italian, a critical question remains: are they truly readable when used in isolation? In a limited sense, the answer is yes: they can be read. Yet they do not provide a transcription that enables someone familiar with the object language to reliably reconstruct the original sign forms and their form-meaning mappings within the context of the utterance (Vermeerbergen 2006; Frishberg, Hoiting, and Slobin 2012; Volterra et al. 2022), especially in the absence of video data (Antinoro Pizzuto, Chiari, and Rossini 2010). Even in the case of so-called "frozen" Lexical Units, the same meaning can be expressed through different signs that are synonymous but vary in their manual and body articulations. If this information is not encoded in the transcription, then VLLs lose their capacity to convey the necessary linguistic detail. As a result, the data ceases to be truly readable, particularly for those seeking to retrieve, analyze or reproduce the original forms.

Given the current context, the most effective approach to annotating sign language data is the integration of both human-readable and machine-readable transcription systems. But how can this be achieved? One viable solution is to combine labelling with language-specific notational systems. In fact, although sign languages lack standardized writing systems, this does not mean they are never written. On the contrary, various notation methodologies have been developed over time. Both deaf and hearing members of international signing communities have devised more or less iconic language-specific methods to address the absence of a standard writing system. Contemporary language-specific systems include Stokoe Notation (Stokoe 2005; Martin 2003), HamNoSys (Prillwitz et al. 1989; Hanke 2004) and SignWriting (Di Renzo et al. 2011; Sutton 2022).

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Figure 1
The LIS sign that can be labelled as *cane* (dog), represented using an adapted version of Stokoe Notation (Bianchini 2023).

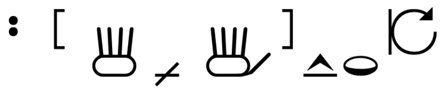

Figure 2
The DGS (German Sign Language) sign that can be labelled as *neunzehn* (nineteen), represented with HamNoSys (Hanke 2004).

Figure 3
The LIS sign translating the phrase *fra poco* (soon/ in a little while) represented using SignWriting (Di Renzo et al. 2011).

While these systems have attained varying degrees of academic recognition, their adoption has remained limited and, at best, scattered, also within the international research community. This restricted use is largely due to the complexity involved in learning these systems, as well as their limited compatibility with widely-employed multimodal annotation tools such as ELAN (Wittenburg et al. 2006). Within this landscape, Typannot (Boutet et al. 2016) emerges as a particularly valuable resource as it offers a hybrid solution that is both human-readable and machine-readable, providing more precise and accessible annotations for computational processing of sign language data.

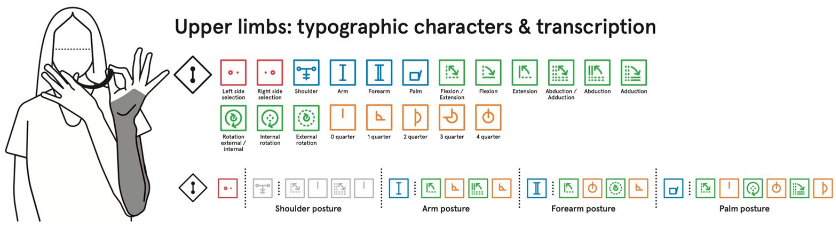

Figure 4
Segment of a Typannot annotation representing the right upper limb transcription for the LIS sign labelled as *'bellissima' (very beautiful)* (Bianchini et al. 2025).

The practical use of this system within the context of this work will be discussed in section 5.4.

4.3 Ethical Considerations

Given the nature of the present research, one should consider not only its intended scientific contribution, but also its possible impact on the minority communities for whom the language is a daily means of communication. Sign languages are not just systems to be analyzed, they are the primary languages of many deaf individuals (and the signing communities they belong to). Research involving these languages should therefore acknowledge the social and ethical responsibilities that come with studying a historically marginalized minority language.

The study and representation of sign languages, particularly through tools developed within computational linguistics, should be approached with critical awareness of the potential for epistemic violence (Branson and Miller 1993; Reagan, Matlins, and Pielick 2021): the imposition of categories, methodologies or technologies that fail to reflect the knowledge, practices or experiences of signing communities. Without the involvement of deaf signers, there is a risk of developing tools that do not align with community needs or values. Such outcomes may result in linguistic resources whose design and implementation exclude meaningful participation and provide little tangible benefit to the communities concerned (Finnish Association of the Deaf 2015).

In line with the statement shared by the disability rights movement *"Nothing about us without us"* (Charlton 1998), researchers should adopt models of co-production, establishing collaborative frameworks in which deaf individuals are not subjects but agents of research. In practical terms, considering the scope of this work, this means that the creation of linguistic corpora or datasets, the development of annotation standards, as well as the design of computational models, should all be informed by the perspectives, priorities and knowledge of sign language users. The key question, then, is not only what can be done *with* sign language data, but also *by whom* , *for whom* and *to what end*.

5. Putting Theory Into Practice Through the MultiMedaLIS Dataset

5.1 From Collection to Annotation

Building on the framework presented in sections 2, 3 and 4, the MultiMedaLIS Dataset was developed as a preliminary resource. The primary objective was to create a testing ground for various theoretical and methodological hypotheses. Specifically, the project aimed to determine (i) whether current recording tools can capture high-quality LIS data, (ii) how such data can be annotated in a manner that is both human and machine-readable and (iii) whether it is possible to train an automatic sign recognition algorithm with this data. In accordance with the background discussed in section 2, the Dataset was created by drawing on prior experiences in multimodal data collection and processing, from both the Italian context (Geraci et al. 2011; Geraci, Mazzei, and Angster 2014a; Mazzei 2015; Lo Re 2022) and the most recent international guidelines for sign language data collections (Hanke and Fenlon 2022; Hodge and Crasborn 2022; Schembri and Cormier 2022).

5.2 Recording Setup and Protocol for LIS Data Acquisition

To address the challenges outlined in section 3, non-invasive and portable recording tools, capable of capturing high-resolution data on the entire body, were selected. This approach was chosen to make sure that the recordings would be able to account for a holistic approach to capturing LIS signs.

The Dataset was recorded using a multimodal setup comprising four different sensors, each contributing complementary streams of visual/spatial information. Manual articulators were captured using the Infineon XENSIV 60-GHz RADAR, which records various types of hand movement data, including time-domain and frequency-domain signals, as well as range-Doppler maps with and without Moving Target Indication (Figure 5), all at a frame rate of 13 frames per second (fps).

Figure 5
Example of XENSIV RADAR data visualization for the MultiMedaLIS Dataset. From left to right: Range-Doppler maps captured by three separate receiving antennas, followed by an MTI (Moving Target Indication) map highlighting motion-based targets.

Upper body positioning and hand configurations were further captured through the Intel RealSense D455 depth camera, which provides multiple and synchronized outputs: stereo infrared images (848×480 pixels, 30 fps), RGB images (1280×720 pixels, 30 fps), standard and filtered depth maps (up to 848×480 pixels, 30 fps) and corresponding 3D point clouds, also supporting face tracking (with 68 facial landmarks per frame). Facial expressions were captured using the Microsoft Kinect v1, which supplied both RGB and depth images (640×480 pixels, 30 fps) along with 87 2D face tracking points. Lastly, full-body spatial information was acquired using the Stereolabs ZED 2 stereo camera, which produces stereoscopic RGB images, 32-bit depth maps, and 3D point clouds at 1920×1080 pixels and 25 fps. It also tracks 18 3D body landmarks, allowing for the annotation of postural and gross motor features relevant to sign language articulation (Figure 6) (Mineo et al. 2024).

Figure 6
Examples of the visual outputs from the multimodal capture setup. From left to right: RGB frame, depth map, infrared stereoscopic image with structured light projection (left sensor), infrared stereoscopic image with structured light projection (right sensor) (Mineo et al. 2024).

Data collection was managed through a custom software, operated via a modified keyboard functioning as a foot pedal system. Participants advanced through the stimulus list[7] using the right pedal, returning to a neutral seated position before and after each sign. Mistakes could be corrected by re-recording via the left pedal. The interface featured background color changes (yellow for preparation, green for recording) to guide the user through each phase and minimize error (Caligiore 2024; Mineo et al. 2024).

7 See section 5.3 for general information on the data, for the complete list, refer to Caligiore et al. (2024) and Mineo et al. (2024).

5.3 Collected Data

The data collection protocol led to capturing a total of 25,830 isolated sign instances, including 205 repetitions of each of 100 signs and the 26 signs of the LIS alphabet, amounting to approximately 7 hours of recorded data. The Dataset includes a broad range of semantic categories relevant to medical communication, encompassing anatomical terminology, symptoms and health conditions, medical procedures, healthcare professionals and facilities, as well as Deictic Units that refer to individuals, temporal expressions, and basic discourse markers. These signs were included to enable, in perspective, the construction of coherent utterances from isolated signs.

The Dataset's semantic scope was deliberately limited to doctor-patient interactions and vocabulary related to COVID-19 symptoms. The choice to focus on healthcare was informed by the critical communication needs observed during the COVID-19 pandemic (Panko et al. 2021; Mazzocca and Ottolini 2022; Mansutti et al. 2023), which highlighted the importance of accessible medical discourse for deaf patients. At the time of the Dataset's development (early 2021 to late 2022), no digital collections of LIS specifically targeting the medical domain were publicly available. As a result, the selection of signs followed a multi-step, data-driven approach. Initially, semantically marked terms were identified through cross-referencing systematic reviews of COVID-19-related symptoms in both Italian and international contexts (Alimohamadi et al. 2020; Riccardo et al. 2020), as well as literature on diagnosis and treatment published from 2020 onwards (Cascella et al. 2023). To expand and validate lexical coverage, the COVID-19 Open Research Dataset (CORD-19) (Wang et al. 2020) was analyzed using corpus management and term extraction tools (Kilgarriff et al. 2004; Caligiore 2024). While no directly comparable corpora exist for LIS, the use of large-scale textual resources enabled the identification of frequently occurring and semantically relevant terms.

Following data collection, the following phase involved processing the recorded material.

5.4 Annotation Structure and Machine Readability

As section 4 discusses, in developing the Dataset, the equally important role of both manual and body articulators was valued. Given its feature that allows to view video data and attach time-bound annotation segments to it, ELAN was selected as the annotation tool. Tokenization of the isolated signs was carried out by identifying the "stroke" phase (Kendon 2004; McNeill 2005), which represents the moment of maximum effort or deviation from a relaxed posture, characterized by hands and arms at rest, an upright torso and a neutral facial expression. The preparation and retraction phases were not included in this analysis.

As for data processing on ELAN, while multiple sensor streams were captured during recording, the manual linguistic annotation was conducted on the RGB video data, as it provided the most accessible and information-rich input for human annotators. This decision was made to safeguard the accurate interpretation of the visual-phonological manual and body elements, which are most reliably perceived in standard video. However, all data streams are time-synchronized, allowing the ELAN annotations to be aligned with the other modalities for future computational use.

Regarding annotation, the Dataset has been partially annotated to render the data accessible to both signers and non-signers, including speakers of Italian and English. To achieve this, multiple annotation layers were implemented in ELAN following the principles of simplicity and readability. To provide the signed data with an accessible transcription for non-signers, two VLL tiers ("Italian VLL" and "English VLL") were added to provide corresponding written translations of the meaning of the sign in the two vocal languages.

“Readability”, in particular, has a two-dimensional meaning in this context. In fact, the annotation architecture was developed with machine-readability as a core design principle. The annotations were created using ELAN, whose .eaf files are XML-based (Wittenburg et al. 2006). This format, together with the annotation methodology employed, ensures that annotations are both human-readable and easily processed by computational tools. Moreover, the template adopted in this project was developed in compliance with best practices in sign language corpus linguistics (Schembri and Cormier 2022; Hodge and Crasborn 2022), employing a hierarchical and modular documented tier system. Each lexical unit is annotated across parallel and interlinked tiers, including ‘Italian VLL’, ‘English VLL’ (Antinoro Pizzuto, Chiari, and Rossini 2008) and ‘Meaning Unit’ (Volterra et al. 2022; Cuxac and Sallandre 2002). The decision to limit the semantic scope of the Dataset resulted in the inclusion of only Lexical Units (LUs) and Deictic Units (DUs). In the annotation process, this distinction was operationalized through the inclusion of a dedicated tier for the identification of the Units, with each sign was accordingly labelled with the code "LU" for Lexical Units or "DU" for Deictic Units.

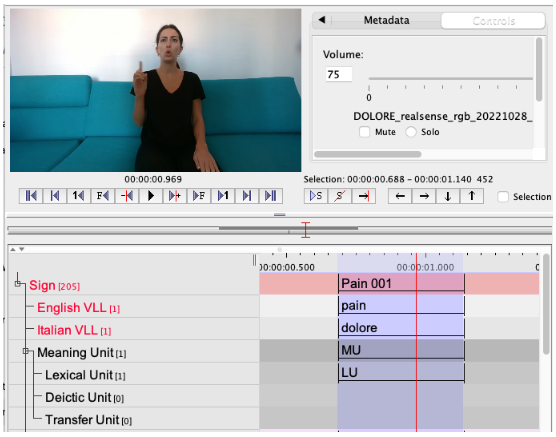

Figure 7
Partial view of the annotation of the sign instance ‘001’ for ’pain’ (*dolore*) in ELAN. The visualization shows the assigned numbered label, VLL in English and Italian and the assigned Meaning Unit.

Additional tiers were used to annotate manual and body articulators. All tiers were explicitly named and hierarchically organized to ensure annotation consistency and to facilitate automatic parsing. As for the information to include in these tiers, a further element supporting computational processing was the use of the Typannot font for formational description. In fact, a key element of the annotation process was the integration of a language-specific and iconic system that is Unicode-compatible (Doan et al. 2019; Boutet et al. 2016; Bianchini 2021, 2023). For mouthings, which relate directly to Italian lexical items, a transcription of the partial or complete articulation of the Italian word was included (Johnston, Roekel, and Schembri 2015; Fontana 2008).

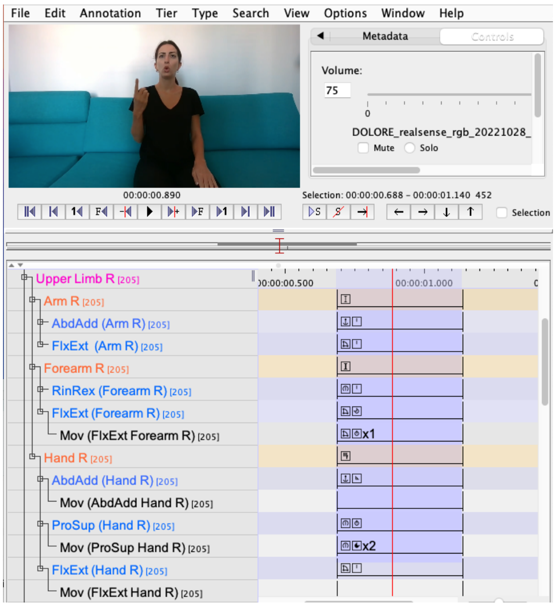

Figure 8
Partial annotation of the sign instance '001' for 'pain' (*dolore*)in ELAN. The visualization displays Typannot values for the right upper limb, corresponding to the stroke phase of the sign.

The entire schema was conceived with extractability and reuse in mind. This includes not only export for statistical or linguistic analysis, but also potential integration with the multimodal data streams which are fully synchronized with the annotated RGB video.

5.5 Sociologically Contextualizing the Dataset

To provide a sociological foundation for the Dataset, a series of actions were taken both prior to and following data collection. These steps aimed to make sure that the Dataset was developed with input from those most likely to use it, and to validate its acceptability within the signing community. Before beginning the data collection, consultations were conducted with representatives of the three main groups involved in communication in medical contexts: a deaf individual, a hearing LIS interpreter and a medical doctor (Raniolo and Gaia 2023). These interviews and discussions helped shape the scope and design of the Dataset by integrating insights from diverse professional and experiential perspectives.

Following data collection, a validation step was carried out to assess the acceptability of the 100 signs included in the Dataset. A questionnaire was administered anonymously to a group of 10 deaf LIS signers. The questionnaire consisted of two parts: the first collected basic demographic information (including deafness status, age and place of birth), while the second focused on participants' evaluations of each sign's acceptability. Results showed that 47 out of the 100 signs were unanimously accepted by all participants. An additional 17 signs received approval from 90% of respondents and 10 signs were considered acceptable by 80% of participants. Together, these three groups account for 74% of the signs assessed. None of the signs were unanimously rejected by all participants, indicating a generally high level of acceptability within the sample.

6. Conclusion

The development of the MultiMedaLIS Dataset intends to prove that it is indeed possible to create high-quality sign language resources with annotations that are simultaneously human and machine-readable. Although the Dataset was developed as a preliminary resource, it provides a practical proof of concept by combining multimodal data with an annotation framework designed to serve both linguistic analyses and technological application. While the Dataset's processing efforts confirm that multilayered annotation is feasible and that initial results in sign recognition are promising, they have also confirmed the need for an iterative commitment to the development of LIS resources to address the gap in resource availability for LIS.

As for current uses, the Dataset is currently being used to train sign recognition algorithms (Mineo et al. 2024; Caligiore et al. 2024) and is scheduled for public release in the near future. This step is very important, as one of the guiding goals behind its development has been to contribute a resource to the body of openly accessible LIS data. Open access in this context is a practical necessity, especially given the under-documented nature of LIS and its status as a minority language. By making LIS datasets publicly available, our research community will be one step closer to gaining the foundation required to develop and assess sign language processing systems, with benefits expanding beyond the LIS research community.

Lastly, the challenges posed by sign languages lead to a critical re-examination of how language, modality and data collection interact. As mentioned in the introduction, adopting a multimodal approach to sign language analysis entails understanding language as a fundamentally face-to-face phenomenon that is inseparable from the sociocultural context in which it occurs. Rethinking the dependencies among language, modality and its collection is therefore not simply a theoretical exercise, or a matter of inclusivity, but rather a necessary 'readjustment' of our frameworks, in order to understand and explore how meaning is conveyed through different modalities.

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