Accommodating Irish Sign Language in an Extended Role and Reference Grammar Lexicon Architecture

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Aim of the Paper

- This research is concerned with the definition of a Role and Reference Grammar (RRG) lexicon architecture (Nolan 2011a, 2011b) to accommodate the linguistic phenomena unique to sign languages, in particular to this research **Irish Sign Language** (ISL), in linguistic terms.

- To date, there is no definition for the architecture of the ISL lexicon in computational terms.

- In pursuit of defining a lexicon architecture to accommodate ISL, we argue that the theory of **qualia structures** defined within the theory of the **Generative Lexicon** (GL) (Pustejovsky, 1991) must to be extended to cater for SLs and their associated linguistic phenomena.

- We propose that **semantic properties**, which contribute to the meaning of a sentence, will need to be extended to accommodate ISL within the lexicon.

Aim of the Paper

- We motivate a new level of lexical meaning termed ***Articulatory Structure Level***, such that the computational phonological parameters associated with this visual gestural language are accommodated.
- We refer to our newly developed linguistically motivated computational framework as the ***Sign_A* framework**, with the "A" within this term representing **Articulatory Structure Level.**
- The Sign_A framework together with Articulatory Structure Level, enables us to provide a definition within **RRG** for the **ISL lexicon** in computational linguistic terms.
- We leverage the Sign_A framework to extend the RRG model to account for lexical entries for **ISL verbs, ISL classifiers** and **ISL nouns** within the RRG lexicon.
- We use the Signs of Ireland (SOI) corpus within this body of work in our analysis of ISL (Leeson et. al, 2006).

Sign Language

- Sign language (SL) is a visual, spatial language, which utilises a combination of body and facial expression, lip formation and hand signs. SLs are fully developed natural languages used by deaf communities all over the world (Gordon, 2005)
- ISL is a linguistically complete, very rich and complex language. ISL is the indigenous language of the **Irish Deaf Community** and is the **first language** of Deaf people in Ireland.
- In terms of production, SLs are articulated in three dimensional space, using not only the hands and arms, but also the head, shoulders, torso, eyes, eye-brows, nose, mouth and chin to express meaning (O'Baoill and Matthews, 2000).
- The visual gestural realisation of a word in SL involves the **simultaneous** and **parallel** expression of a varied number of MFs and NMFs, each with their own duration, orientation and relative configuration and movement.

Sign Language Morphology

- The **morphology** of sign languages is concerned with manual features (MFs) and non-manual features (NMFs). The existence of MFs and NMFs within signed languages has been well documented by researchers (Stokoe (1960), Liddell (1977), Sutton-Spence and Woll (1999), Valli and Lucas (1995), Battison (1978), Nolan (1993), Coerts (1990), Bellugi and Klima (1990), Baker and Padden (1978) Sutton-Spence and Boyes-Braem (2001), Fitzgerald (2014), Mohr (2014).

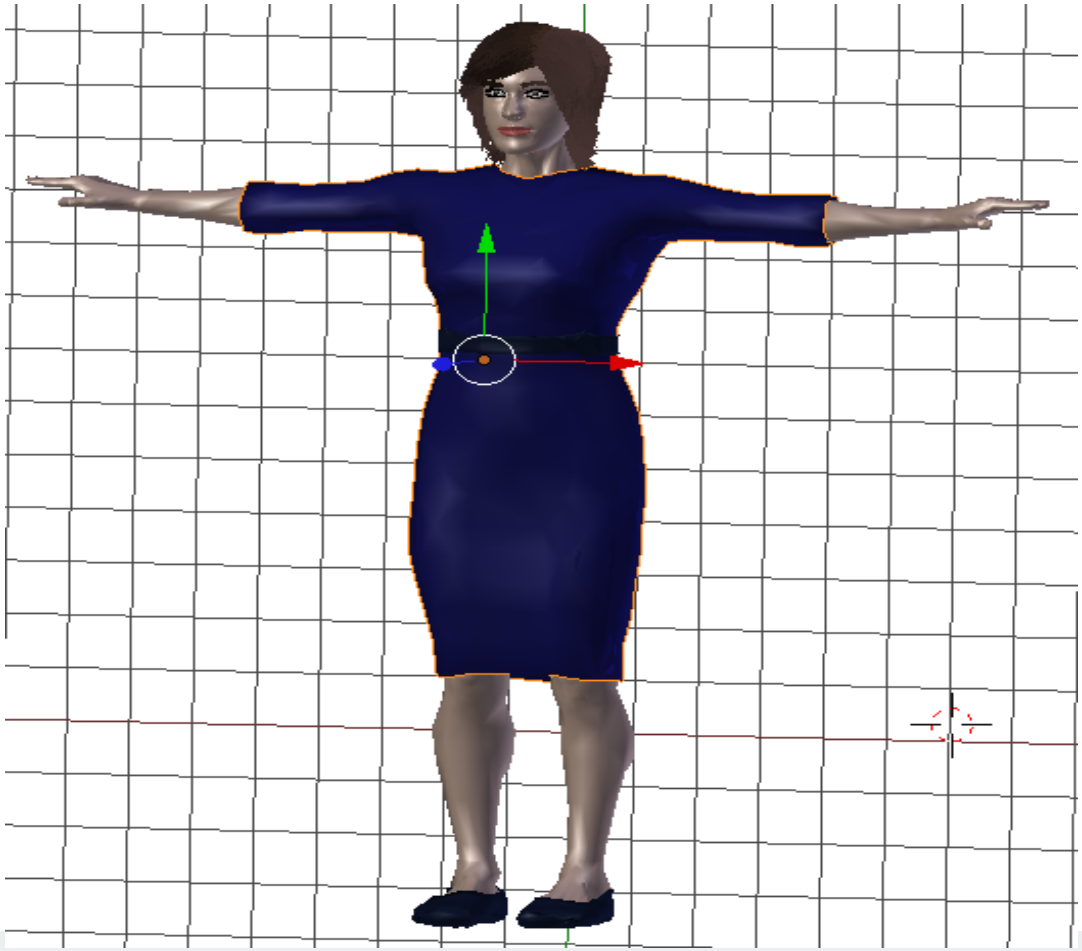
- **MF phonological parameters** can be defined as *handshape* or *relative configuration, location, orientation, movement* and (Murtagh 2019: 96).

- **NMF phonological parameters** can be defined as *eyebrow movement, movement of the eyes and eyelids, mouth patterns, tongue movement, blowing of the cheeks* and also *head tilting* and *shoulder movement* (Murtagh 2019: 96).

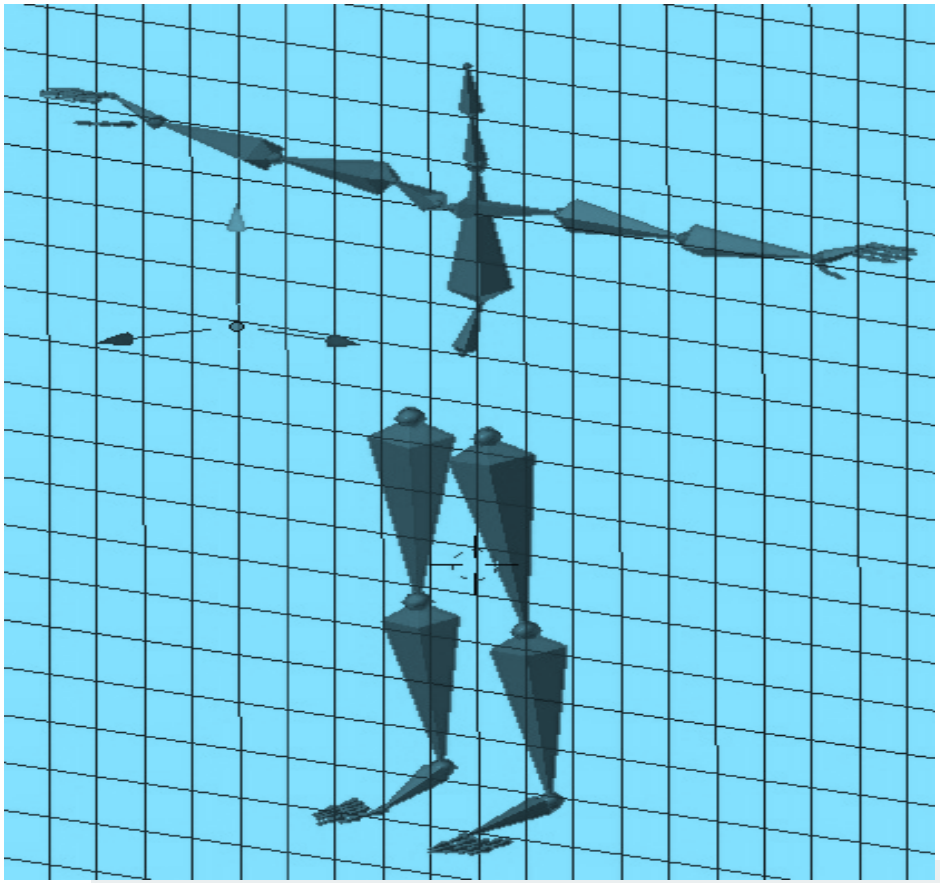
The Phonological-Morphological Interface in ISL

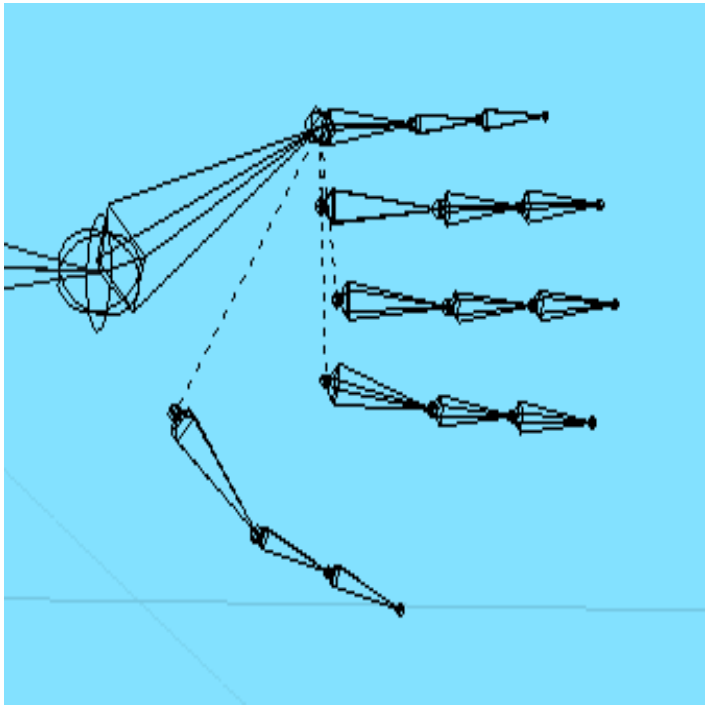
- Prior to preparing a linguistically motivated computational definition of **lexicon entries** that are sufficient to represent ISL we first define ISL phonological parameters in computational terms (Murtagh, 2015).
- The computational parameters will be used to serve as a motivation and to inform the design of the **Articulatory Structure Level** and other **related theoretical extensions**.
- We must be able to **refer to the various articulators** (hands, fingers, eyes, eyebrows etc.), as these are what we use to communicate the various phonemes, morphemes and lexemes of an utterance (Murtagh 2011).
- Due to the visual gestural nature of ISL, and the fact that ISL has **no written or aural form**, in order to communicate an SL utterance we must define a humanoid model or avatar within three-dimensional (3D) space.
- Using our avatar, we have the ability to identify the parameters necessary for the **robust extension of RRG** through the **extension of qualia theory** and its interface with the lexicon.

The ISL Avatar



Avatar Armature





Articulatory Structure Level

- In terms of the development of a linguistically motivated computational framework for ISL, a list of ISL phonological parameters for both MF and NMF have been rigorously described and defined in computational terms (Murtagh, 2015).

- With regard to **MF** computational parameters, we include **handshape, hand movement, palm orientation, arm movement, forearm, upperarm, event duration, timeline duration, signing space location and also a listing of body anchored locations.**

- With regard to **NMF** computational parameters, we include **head, eyebrow, eyelid, eye gaze, cheek, mouth, tongue, nose and shoulder** parameters. The event duration and timeline parameters are used for NMFs also.

Articulatory Structure Level

Parameter	Computational Parameter Subcategories
Handshape **<HS>**	f1Shape(xi,yi,zi)…. f1Shape(xn,yn,zn) f2Shape(xi,yi,zi)…. f2Shape(xn,yn,zn) f3Shape(xi,yi,zi)…. f3Shape(xn,yn,zn) f4Shape(xi,yi,zi)…. f4Shape(xn,yn,zn) tShape(xi,yi,zi)…. tShape(xn,yn,zn) tOverLap(xi,yi,zi)…. tOverLap(xn,yn,zn) tPalm(xi,yi,zi)…. tPalm(xn,yn,zn) eventDuration(EDti, EDtn) timeline(TLti, TLtn) **hsDef((f1Shape_i, f1Shape_n, eventDuration(EDti, EDtn)),** **(f2Shape_i, f2Shape_n, eventDuration(EDti, EDtn)),** **(f3Shape_i, f3Shape_n, eventDuration(EDti, EDtn)),** **(f4Shape_i, f4Shape_n, eventDuration(EDti, EDtn)),** **(tShape_i, tShape_n, eventDuration(EDti, EDtn)),** **timeLine(TLti, TLtn))**

Articulatory Structure Level Temporal Parameters

- The order or linear sequence in which these computational phonological parameters (distinct from one another) are realised along a timeline is significant with regard to the **syntax and semantics** of SL. The parameters that are required to adequately represent ISL can be described more easily if one uses the analogy of instruments playing together in an orchestra.

- The capacity to generate a signed utterance can be likened to this analogy, where the various articulators would be represented by the instruments and each articulator will play its own part in producing an overall production or articulation, similar to the instruments playing their parts in an orchestra.

- The **event duration** parameter (EDtn) will be used to account for the duration of time for any given MF or NMF to be realised.

- The **timeline** paratemer (TLtn) refers to the overall timeline of an utterance and is responsible for the synchronisation and keeping track of the sequence of each phonological event, defining at which point along the overall timeline an event may be realised.

Articulatory Structure Level

- Bearing in mind the computational parameters necessary to represent ISL, and taking into account Pustejovsky's (1991a) proposal that lexical meaning can be best captured by assuming four levels of lexical representation, we propose that in order to develop a lexicon architecture that is sufficiently universal and robust to accommodate the linguistic phenomena associated with sign language, the number of levels available within the GL theory should be extended from four levels to five (Murtagh, 2015).

- **Articulatory Structure Level** describes the essential (computational) phonological parameters of an object.

- Note: **Articulatory Structure Level** was previously termed phonological structure level (Murtagh, 2015), however on reflection we have modified this term to **Articulatory Structure Level**.

Articulatory Structure Level

Lexical Representation Level	Description
Argument Structure	The behavior of a word as a function, with its arity specified. This is the predicate argument structure for a word, which indicates how it maps to syntactic expressions.
Event Structure	Identification of the particular event type (in the sense of Vendler (1967)) for a word or phrase: e.g. as state, process, or transition.
Qualia Structure	The essential attributes of an object as defined by the lexical item.
Inheritance Structure	How the word is globally related to other concepts in the lexicon.
Articulatory Structure	The essential (computational) phonological parameters of an object as defined by the lexical item.

Five levels of lexical representation for ISL

- We use our proposed Articulatory Structure Layer to allow us to cater for the linguistic phenomena associated with ISL in the development of ISL verb, classifier and noun lexical entries within the Sign_A Framework.

Defining RRG Logical Structures for ISL Verbs

- Classification of verbs within SL is traditionally described according to Padden's classical **tripartite classification of verbs** based on American Sign Language (ASL) (Padden, 1988). Verbs can be described according to this classification as plain, agreement or spatial.

- ISL verbs for analysis were taken from the ISL corpus (Leeson et.al, 2006) and also literature within the field (McDonnell 1996). ISL verbs were initially categorised according to their **tripartite verb category**.

- These verbs were then further investigated and categorised according to their ISL morphological verb class (Leeson and Saeed 2012; McDonnell 1996).

- Bearing in mind that RRG semantic representation is based on a system of lexical representation and semantic roles and that RRG employs the system of lexical decomposition proposed by Vendler (1967) we then investigate the verbs further to determine their associated Aktionsart classification or situation type (Vendler 1967).

RRG Logical Structures for ISL Verbs

- On investigation of **ISL ver**bs and the associated **Aktionsart classes** it was found that ISL shows linguistic correlates for **five** situation types: states, activities, achievements, accomplishments and semelfactives.
- Example 1 and 2 following provide an illustration of RRG logical structures for ISL plain **verbs**, while the subcategories that sit behind the <MF> and <NMF> parameters follow in Examples 3 and 4.
- Note: Plain verbs do not encode any grammatical features of their arguments. They do not give morphological information of person and number by movement and do not show agreement with either subject or object. Plain verbs are uninflected and do not take agreement affixes.

RRG Logical Structures for ISL Verbs

Example 1	**Example 2**
State	Activity
REAL LIKE MY JOB	SOME BOY THINK
‘I really love my job’	‘Some boys think’
LIKE´ <TLine><MF><NMF> (1sg, JOB)	**do’**(BOY.pl,[**THINK’**<TLine><MF><NMF> (BOY.pl)])
SOI Corpus Noeleen (03) Personal Stories (Dublin)	SOI Corpus Noeleen (03) Personal Stories (Dublin)

RRG Logical Structures for ISL Verbs

- **Example 3**

<MF>(<HS><ORI><WRIST><F_ARM><U_ARM>)

- **Example 4**

<NMF>(<HEAD><EB><EL><EG><CHEEK><MOUTH><TONGUE><LSHOUL><RSHOUL>)

RRG Logical Structures for ISL Verbs

- Example 5 following provides the proposed RRG logical structure for an **ISL agreement verb** based on the associated situation type.
- This example is of the ISL agreement verb ACCUSE, which has a situation type of activity. The signer (c referring to canonical locus) is situated within the ^{a} locus in this example, which has a location in front of the signer's chest. The movement is towards the ^{b} locus (in this case f or forward locus representing YOU). Movement occurs from ^{a}locus to ^{b}locus.

RRG Logical Structures for ISL Verbs

Example 5 Activity (double person agreement)

c+ACCUSE+f

'I blame you'

McDonnell (1996: 160, Example 5.62)

do'(1sg , [**^{a}ACCUSE'^{b}** <TLine><MF> <LOC> <NMF> **(**^{a}1sg , ^{b}2sg)])

<HS> both hands[24]

<LOC> (^{a} c locus or body chest, converts to L1 on Sign_A allocation map) (^{b} pronominal reference (you), converts to L2_mid on Sign_A map) // marks for source and goal or subject and object

<HMOV> from point a to point b //shows direction

<ORI> palm down, fingertips forward

RRG Logical Structures for ISL Classifiers

- **Example 6**

_____puff cheeks

dh: V-CL+BENT +(f+MOVE-horizontal-circle +sl+horizontal orientation)

nh: V-CL+BENT +(f+MOVE-horizontal-circle +sr+orientation-sr+hi)

'He explored the area'

^{xa} V-CL+BENT +(f+MOVE-horizontal-circle +sl).V-CL+BENT +(f+MOVE-horizontal-circle+sr)$^{b'}$ <TLine><MF><NMF> (^{xa}3sgM, horizontal orientation-sl. orientation-sr+hi ^{b})

RRG Logical Structures for ISL Classifiers

- In Example 6, the classifier handshape (which is categorised in ISL as an +animate person two legs whole entity classifier) is represented as the ^{xa}locus entry in the LS . The x in this case is used to associate the ^{xa}3sgM LS entry with the entity introduced earlier in the discourse i.e. the signer's husband. This ^{x} depicts and is a reference to the signer's husband. The ^{a} in the ^{xa}3sg LS entry denotes the reference to classifier handshape [47], in Figure 6.2, now representing the husband entity.

- This classifier handshape argument represents the theme or subject of the ISL sentence and is used to denote the the husband exploring the area. The location of the ^{b}locus (^{b}the area), the place in 3D space on the palm of the signer's two hands that the V-CL moves around i.e. the horizontal orientation for the dominant hand and orientation to the signer's right and upwards for the non-dominant hand.

RRG Logical Structures for ISL Nouns

- Bearing in mind the computational phonological parameters necessary to represent a nominal in ISL and taking into account Pustejovsky's theory of qualia, which posits that lexical meaning could best be captured by assuming four levels or roles as representation for a noun (Pustejovsky, 1991), it is proposed that in order to create a lexicon architecture which is sufficiently rich and universal in nature to capture the linguistic phenomena consistent with ISL, that qualia within the GL framework should be extended.

- We provide an illustration of our proposal for extension to qualia to take into account the **Articulatory Structure Level** proposed previously

RRG Logical Structures for ISL Nouns

- REF_{LOC} refers to an (x, y, z) reference and represents the locus or (x, y, z) location parameter in space in which a specific entity has been established previously within the discourse. In terms of qualia, we must extend the definition of lexical items to cater for ISL nouns, catering for the visual gestural modality of the language and the fact that once an entity such as a noun is established within the discourse, the position within 3D space can be used as a method of referencing this entity.

- We do this at the point of definition of the entity, where we also allow for a reference parameter or a locus parameter, which is a place holder in 3D space for the specific location that the entity exists. This parameter allows us to reference the location of an entity within the discourse if necessary.

- Due to the visual gestural nature of ISL and ISL nouns, we extend constitutive, formal, agentive and telic role to allow these to cater for the linguistic phenomena pertinent to an ISL noun. We use the Articulatory Structure Level for lexical meaning, and also propose a reference parameter (REF_{LOC}), which will store the (x,y,z) co-ordinates of the location within 3D space that the noun exists and can be referenced at.

RRG Logical Structures for ISL Nouns

DINNER (REF y)

Const: **food items,…..**(REF y)

Form: **physical**(REF y [<TLine><MF><NMF>])

Telic: **do** (x, [**EAT**<TLine><MF><NMF> (x, REF y)])

Agentive: **MAKE** (REF y), BECOME **MAKE**<TLine><MF><NMF> (REF y, dinner)

Concluding Discussion

- It is important to mention at this juncture the implications that **Articulatory Structure Leve**l may have with regard to spoken language linguistics. Although spoken language occurs within a vocal-auditory modality compared with SL, which occurs within a visual-gestural modality, it is proposed that **Articulatory Structure Level** has the potential to lend itself well in terms of the representation of spoken language linguistics.

- Vermeerbergen et al. (2007: 4) report that "the amount of simultaneous structuring in spoken language depends on which aspects of spoken language communication one considers to be part of language". As a consequence of this Vermeerbergen et al. (ibid.) report that it is "not possible to draw a simple contrast between highly simultaneous signed languages and highly sequential spoken languages".

- While SLs display simultaneity in their structure (Sandler and Lillo-Martin, 2006) early on in spoken language literature, spoken languages displayed relatively little in terms of simultaneity but were seen as being characterised by the many sequential phenomena that occur (Levelt, 1989). However, later on in the literature it became increasingly more acceptable that gesture and non-verbal communication were an important part of face-to-face spoken language communication (McNeill, 1992; Ní Chasaide and Gobl, 1990).

Concluding Discussion

- Gobl and Ní Chasaide (2010) report that "variations in the voice source may be associated with segmental or suprasegmental aspects of the linguistic code".
- Gobl and Ní Chasaide (ibid.) identify that voice quality and the paralinguistic aspects of voice source variation can be used signal a speakers mood and emotion as well as attitude to the interlocutor.
- Voice source variation may also have a sociolinguistic function allowing differentiation between linguistic, regional and social groups.
- Although the focus of this study is concerned with the definition of a Role and Reference Grammar (RRG) lexicon architecture (Nolan 2011a, 2011b) to accommodate the linguistic phenomena unique to sign languages, it would seem that Articulatory Structure Level may have the potential to lend itself well in catering for phenomena such as prosody, gesture and non-verbal communication within the realm of spoken language linguistics with regard to future research.

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Thank you!