

A Linguistically Motivated Computational Framework for Irish Sign Language

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Declaration

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Abstract

This research is concerned with the development of a linguistically motivated computational framework for Irish Sign Language (ISL) and defining a lexicon architecture that is sufficiently universal and robust to accommodate the linguistic phenomena pertinent to sign languages, in particular to this research ISL, in linguistic terms. To date, there is no definition for the architecture of the ISL lexicon in computational terms.

ISL is a visual gestural languages articulated in 3D space with no written or aural form. ISL is a linguistically complete, very rich and complex language. Communication across sign languages occurs using visual-gestural modality, encompassing Manual Features (MFs) and Non-Manual Features (NMFs). MFs include hand shapes, hand locations, hand movements and orientation of the palm of the hands. NMFs include the use of eye gaze, facial expression, mouthing, head and upper body movements. 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.

The four research questions that this dissertation addresses are:

RQ1. To what extent can RRG account successfully for ISL sentence structure?

RQ2. How do we motivate the phonological-morphological interface in ISL?

RQ3. How might lexical entries look for ISL classifiers, ISL verbs and ISL nouns within the RRG lexicon?

RQ4. What is the appropriate linguistically motivated computational architecture for ISL and where within this architecture should the ISL grammatical morpheme repository reside?

We will seek to implement a humanoid avatar, constrained in 3D space similar to human muscular skeletal constraints and we will utilise this avatar to motivate the design of our lexicon architecture for ISL. We endeavour to utilise Role and Reference Grammar (RRG), a structural functionalist theory of grammar and a functional model of language in the development of our linguistically motivated

computational framework. We will utilise the Signs of Ireland (SOI) corpus in our analysis of ISL.

In our pursuit of defining a lexicon architecture that is sufficiently universal and robust in nature to accommodate ISL we argue that the theory of qualia structures defined within the theory of the Generative Lexicon (GL) must to be extended to cater for SLs and their associated linguistic phenomena. We have argued that semantic properties, which contribute to the meaning of a sentence, will need to be extended to accommodate ISL. 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 sufficiently accommodated. This level of lexical meaning will represent the essential (computational) phonological parameters of an object as defined by the lexical item. These parameters will be used to account for various linguistic phenomena pertaining to ISL MFs and NMFs, which are necessary to adequately represent ISL within our computational framework. We refer to our newly developed framework as the Sign_A framework, with the “A” within this term representing Articulatory Structure Level. We leverage our proposed Articulatory Structure Level for lexical meaning to accommodate the linguistic phenomena consistent with ISL and to develop a lexicon architecture capable of accommodating ISL in computational linguistic terms.

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Dedication

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Abbreviations

ISL	Irish Sign Language	LDP	Left detached position
3D	Three-dimensional	RDP	Right detached position
MF	Manual Feature	NUC	Nucleus
NMF	Non Manual Feature	PrCS	Precore slot
RRG	Role and Reference Grammar	PoCS	Postcore slot
HPSG	Head Driven Phrase Structure Grammar	LSNP	Layered Structure of the Noun Phrase
ELAN	EUDICO Linguistic Annotator	NP	Noun Phrase
EUDICO	European Distributed Corpora Project	LSC	Layered Structure of the Clause
RQ	Research Question	ADV	Adverb
BC	Before Christ	ARG	Argument
LSF	French Sign Language	PP	Preposition
BSL	British Sign Language	PRED	Predicate
HamNoSys	Hamburg Notation System	LS	Logical Structure
c	Canoninical locus	SUBJ	Subject
sr	Signer right side locus	ING	Ingressive
+++	Reduplication	AUH	Actor Undergoer Hierarchy
ASL	American Sign Language	IK	Inverse Kinematics
CL	Classifier	EVH	Event Visibility Hypothesis

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1. Introduction

1.1 Background

This research study is concerned with the architecture of a lexicon for sign language (SL), in particular Irish Sign Language (ISL) and the challenges involved in the development of a lexicon that is capable of representing lexical information pertinent to ISL and the lexical definition of a SL word (Zeshan, 2007).

SLs are visual gestural languages articulated in a signing space (Murtagh 2011a, 2011b, 2011c). SLs have no written form. ISL (O’Baioill and Matthews, 2000; Leeson and Saeed, 2012) is a linguistically complete and very complex language. Communication occurs using a visual-gestural modality, encompassing manual and non-manual gestures. Manual gestures make use of hand forms, hand locations, hand movements and orientations of the palm. Non-manual gestures include the use of eye gaze, facial expression, head and upper body movements.

The *MF* phonemes of ISL include hand-shape, location and position of the hands in relation to the signer’s body, movement of the hands and also palm orientation. The *NMF* phonemes are eye movement, eyebrow movement, blowing of cheeks, lip movement, head tilt and position and also upper body and lower body movement (Leeson and Saeed, 2012).

The visual gestural realisation of a word in SL involves the simultaneous and parallel expression of a varied number of manual and NMFs, each with their own duration, orientation and relative configuration.

One of the main questions this research addresses is: “What would the lexicon architecture look like if it were developed to accommodate SL?” and how can we meaningfully motivate extending the current theory of the lexicon so that it is universal enough in its nature to accommodate these linguistic phenomena that are necessary to articulate and communicate meaningful discourse in ISL?

1.2 Motivation

Unfortunately, even with today’s technological advancements in both computer hardware and software, the Deaf community in Ireland is still overlooked with

regard to the provision of public services in ISL (O'Baoill and Matthews, 2000). Insufficient socio-economic opportunity occurs within the Deaf community as a result of lack of access to information and communication services. While ISL is used by approximately 6,500 Irish Deaf people, with approximately 5,000 Deaf ISL users in the Republic and 1,500 users in Northern Ireland (Leeson and Saeed, 2012), it is estimated that some 50,000 people also know and use the language, to a greater or lesser extent. SL interpreters are used as a means of communication between the Deaf and hearing, however, in Ireland where the ratio of interpreters to Deaf people is about 1:45 (Leeson and Venturi, 2017), interpreters can be difficult to come by. ISL can be described as a minority language and therefore there is currently no real framework in place to describe its architecture.

As described later in chapter 2 the study of ISL linguistics is still in its early stages. The main motivation for this study is to accumulate a greater knowledge and understanding of the linguistic phenomena that are pertinent to ISL and to develop a lexicon architecture that is sufficiently universal with regard to content to accommodate ISL. Preparing a formal definition of a lexicon architecture has the potential to help alleviate the communication barrier for ISL as a greater understanding of the linguistics of this very rich and complex language coupled with development of a computational model will allow for the construction of synthetic sign generation for ISL. While the World Federation of the Deaf [WFD] and the World Association of Sign Language Interpreters [WASLI] have cautioned against the use of signing avatars in place of human signer's, it is envisaged that this research work will have the potential to allow for the development of avatar technology that will not take the place, but rather work alongside human signer's, taking into account the linguistics of this very rich and challenging visual gestural language.

1.3 Objectives

The objectives of this dissertation are to develop a computational linguistic framework that is sufficient in its capacity to represent SL, in particular to this research ISL, in linguistic terms. Since the discovery that SL was a real human language and the subsequent dawning of SL research approximately 60 years ago (Tervoort 1953; Stokoe, 1960), a wealth of research on the various linguistic

phenomena associated with the SLs of the world has been conducted. ISL is just one of these languages, and although considerable research has been carried out in the area, none has as of yet resolved the issue of the architecture of the ISL lexicon in computational terms. ISL is a visual gestural language articulated in 3D space with no aural or written form. The objective of this research is to define a lexicon architecture that is sufficiently universal and robust to accommodate the linguistic phenomena consistent with ISL.

1.4 Hypothesis

Our hypothesis is that Role and Reference Grammar (RRG), a structural functionalist theory of grammar and a functional model of language is the most appropriate framework for utilisation in the development of our computational linguistic framework. RRG utilises the theory of qualia (Pustejovsky, 1991), as a method of characterising the semantics of nominals. Qualia theory is used within RRG logical structures to represent the semantic properties of nouns that contribute to the interpretation of a sentence. In our quest to appropriately represent ISL in linguistic terms we posit that the theory of qualia structures defined within the theory of the Generative Lexicon (GL) (Pustejovsky, 1995), will need to be extended to cater for SLs. We posit that semantic properties that contribute to the meaning of a sentence will need to be extended to accommodate ISL. We also posit that in terms of lexical meaning for ISL that we will need to develop a new layer of lexical meaning, such that the phonological parameters associated with this visual gestural language are sufficiently accommodated.

1.5 Research Questions

To support our hypothesis we need to address four research questions:

RQ1. To what extent can RRG account successfully for ISL sentence structure?

RQ2. How do we motivate the phonological-morphological interface in ISL?

RQ3. How might lexical entries look for ISL classifiers, ISL verbs and ISL nouns within the RRG lexicon?

RQ4. What is the appropriate linguistically motivated computational architecture for ISL and where within this architecture should the ISL grammatical morpheme repository reside?

1.6 Methodology

In this section we discuss the methodology in this research study. We specifically look at the ISL data and resources used and provide references to literature used within the field. We discuss what data was used and how we approached the analysis of this data. We also discuss the theoretical framework used and the approach taken in development of our three dimensional avatar.

We use RRG (Van Valin and La Polla, 1997) in the development of our computational linguistic framework for ISL. RRG views language as a system of communicative social action. RRG defines grammatical structures in relation to both semantic and communicative functions. Syntax is viewed as being relatively motivated by semantic and pragmatic factors. RRG is sufficiently flexible and robust to accommodate ISL at a semantic, syntactic and pragmatic level. It allows us to address certain characteristics that have proven problematic for head driven phrase structure grammar (HPSG), which was utilised in recent times in the development of a computational lexicon for British Sign Language (BSL) (Sáfár and Glauert, 2012). Many of the rules found in the HPSG literature do not apply to SLs, and it is proposed that to adequately represent this visual gestural language, these rules need to be extended or replaced. Logical structures for RRG will be expanded to cater for ISL allowing us to develop a lexicon architecture that is sufficiently universal in its nature to cater for the linguistic phenomena pertinent to this linguistically rich and highly complex language.

We use the Signs of Ireland corpus (SOI) to access the relevant linguistic data pertinent to ISL (Leeson et al, 2006). We use ELAN software as an application tool, which allows us to view the corpus and collate relevant linguistic phenomena pertinent to ISL. We also look to the literature in relation to ISL. Further information on the data used and the approach to using data within this development can be found in section 1.6.1 and section 1.6.3 below.

We develop a 3D humanoid character to motivate our analysis using MakeHuman [MakeHuman] and Blender [Blender] as our core technologies. Prior to preparing a linguistically motivated computational definition of lexicon entries that are sufficient to represent ISL we must first define ISL phonological parameters in computational terms. 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 use a humanoid model within three-dimensional (3D) space similar to human skeletal constraints. In order to define a linguistically motivated computational model we must be able to refer to the various articulators (hands, fingers, eyes, eyebrows etc.), as these are what we use to articulate various phonemes, morphemes and lexemes of an utterance (Murtagh 2011a, 2011b). We use our humanoid model as a tool for analysis of the interface between morphology and phonology and to accommodate the development of a formal description for the computational phonological parameters utilised in our proposed *Articulatory Structure Level* of lexical meaning.

We utilise our humanoid avatar to motivate the development of our lexicon architecture for ISL. We implement the 3D computational parameters as a representation of our humanoid avatars limbs. The computational phonological parameters for ISL MFs and NMFs are defined within a framework, which we refer to as *the Sign_A framework*, where the “A” within this title refers to *Articulatory Structure Level*.

The development of the avatar in this research study provides us with 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 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. It is likely that Articulatory Structure Level will have potential implications for spoken as well as signed language. We provide a discussion on this in our summary of chapter four in section 4.8.

We extend the generative theory of the lexicon and qualia theory (Pustejovsky, 1995) in the development of our new level of lexical meaning to cater for the linguistic phenomena consistent with ISL (Articulatory Structure Level). We characterise important elements of ISL, using the RRG linguistic framework, while

leveraging this new level of lexical meaning and our extension to qualia theory to define a lexicon architecture that is universal enough in nature to represent the linguistic phenomena associated with ISL, a visual gestural language with no written or aural form.

1.6.1 ISL Data Sources

We use the SOI corpus in the development of our linguistically motivated computational framework (Leeson et al, 2006). We employ ELAN software as an application tool, which allows us to view the corpus and collate relevant linguistic phenomena pertinent to ISL. ELAN is software program developed by the Max Planck Institute in Nijmegen, Netherlands. The SOI corpus is part of the Languages of Ireland programme, at the School of Linguistic, Speech and Communication Sciences, Trinity College Dublin (TCD). We also utilise relevant literature within the domain of ISL from authors such as Leeson (2001, 2004), Leeson and Saeed (2012), McDonnell (1996), LeMaster (1990), Thorvaldsdottir (2010), Matthews (1996a, 1996b, 2005), O'Baoill and Matthews (2000), Mohr (2014), Mohr-Millitzer (2011), Fitzgerald (2014) and Murtagh (2011a, 2011b, 2011c, 2013, 2015).

1.6.2 Theoretical Framework

RRG is a monostratal theory, positing a single syntactic representation for a sentence, linked directly to a semantic representation by means of a bi-directional linking algorithm. RRG has a rich theory of the lexicon. The syntactic representation of clause structure in RRG is referred to as the layered structure of the clause (LSC). RRG also posits a layered structure of the noun phrase LSNP, which is similar but not identical to the LSC. The RRG lexicon, the LSC, LSNP together with the bi-directional linking system and semantics to syntax interface provide us with a theory of grammar that will allow us to cater for the various linguistic phenomena associated with ISL within our framework. Further discussion on RRG, the theoretical framework for this study, is provided in chapter three. Logical structures for RRG are expanded to cater for ISL, allowing us to develop a lexicon architecture that is sufficiently universal in its nature to cater for the linguistic phenomena pertinent to this linguistically rich and highly complex language. Chapter five and chapter six are concerned with RRG logical structures

for ISL verbs and classifiers. ISL noun lexical entries are catered for in chapter seven while chapter eight is concerned with the LSC and the LSNP. Finally, chapter nine caters for the morpheme and lexeme repository and the architecture of our proposed linguistically motivated computational framework, the Sign_A framework.

1.6.3 Approach to Analysis

We provide an analysis of the SOI corpus and of the literature within the field in relation to the linguistic phenomena associated with ISL. Johnston et al. (2007: 163 -169) outline the difficulties involved in the analysis of SLs. With regard to our analysis of ISL verbs and nouns and data used we look initially to the SOI corpus for data examples as we can provide still images of the phenomena, together with a glossed example and the English translation. Where we use data from the SOI corpus we also provide a reference to the participant, the data source number and also location information. All of this information is provided by the SOI corpus.

With regard to glossing, Pizzutto and Pietrandres (2011) identify the difficulties that can occur when glossing SL data with English tags. Taking this into account we provide as many images from the original SOI data source as is possible due to the visual gestural nature of the language. Similar to Leeson and Saeed (2012) we follow Johnston (2001) in our approach to glossing. In an attempt to limit imposing variable lexical and grammatical information on the data, sentences were glossed using an ID gloss for all variations of a single form.

Where certain examples are particularly relevant, we also use literature from the field in the development of this framework, referencing them appropriately.

With regard to our approach to analysis, we select approximately twenty examples of verbs, nouns and classifiers or complex predicates from the SOI corpus and also from the literature based on their appropriateness of coverage of the phenomena under investigation. Once our dataset is established, based on the SOI corpus and also the literature, we begin our investigation. We categorise verbs these 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). We then investigate if the verbs are intransitive, transitive

or ditransitive. 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). The relevant situation type is determined depending on the features displayed by the verb. Available features of the verb include [$\pm$ static], [$\pm$ punctual], and [$\pm$ telic] (these are discussed further in Chapter Three). Based on the features applied, the verbs are then classified as having a situation type of either state, activity, achievement, accomplishment, active accomplishment or semelfactive. Once the nature of a lexical entry for ISL is analysed, 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.

1.7 Organisation of the Research Study

Chapter 1 provides an introduction and also provides the motivation, objectives, hypothesis and research questions for this dissertation.

Chapter 2 provides an account of the evolution of ISL. We discuss ISL handshapes, hand configuration and also manual and NMFs pertinent to ISL. This chapter facilitates our understanding and recognition of the validity of ISL as an entirely complete and complex language in its own right. In doing so we can recognise and appreciate the inherent difficulties involved in developing a lexicon architecture for ISL.

Chapter 3 provides an account of Role and Reference Grammar (RRG). RRG is a functional model of grammar developed by William Foley and Robert Van Valin Jr. in the 1980's. RRG incorporates many of the viewpoints of current functional grammar theories. RRG takes language to be a system of communicative social action, and accordingly, analysing the communicative functions of grammatical structures plays a vital role in grammatical description and theory from this perspective.

Chapter 4 provides an account of our proposed lexicon morphological/phonological interface in computational terms. In order to define a linguistically motivated

computational model of a lexicon we must be able to refer to the various articulators (hands, fingers, eyes, eyebrows etc.), as these are what we use to articulate various phonemes, morphemes and lexemes of an utterance. We begin by preparing a humanoid model within three-dimensional (3D) space and proceed by looking to the various phonological parameters for ISL manual and NMFs. We propose a method of representation of these linguistic components in computational linguistic terms, while also mapping out the signing space in computational terms. We define new parameters for *timeline* and *duration* and identify that in order to truly represent ISL in a lexicon architecture that is universal enough in nature to accommodate ISL in terms of its visual gestural modality, we must allow for an additional level of lexical representation in terms of the generative lexicon theory.

In chapter 5 we further investigate ISL verbs with a view to articulating the linking system from the lexicon to include extended lexical representation into spatial visual syntax for ISL verbs. In this chapter we address RQ3. We provide a definition for the structure of lexical entries for ISL verbs. We initially investigate the linguistics of ISL verbs. We proceed by investigating more recent advances in the literature in this area. In order to provide background on our analysis of ISL verbs we must first outline the morphological and grammatical information that can be found in ISL verbs. We look here to grammatical categories of tense, aspect, manner and number in ISL and describe how these inflectional features are marked in visual gestural modality. We provide an account of how ISL verbs may be represented within the lexicon in linguistically motivated computational terms. We investigate the possibility of extending Pustejovsky's theory of lexical semantics to account for the linguistic phenomena consistent with ISL verbs. We utilise RRG and the Event Visibility Hypothesis (EVH) (Wilbur, 2008) in the development of our proposed lexicon architecture. On investigation of ISL verbs and the associated Aktionsart classes (Vendler 1967) we identify that ISL shows linguistic correlates for five situation types: states, activities, achievements, accomplishments and semelfactives. On analysis of ISL verbs in relation to Wilbur (2008) and the EVH, we identify ISL verb behavior is in agreement with Wilbur's hypothesis.

In chapter 6 we will investigate ISL classifier predicates with a view to articulating the linking system from the lexicon to include extended lexical representation into

spatial visual syntax for ISL classifiers. We look to the literature in relation to the various terminology used to refer to these linguistically complex constructions. We propose that within this body of work the most appropriate term to use relating to these complex constructions is *classifier constructions*. In this chapter we address RQ 3. We provide a definition for the structure of lexical entries for ISL classifiers. In order to provide background on our analysis of ISL classifiers we first outline the morphological and grammatical information that is encoded by these complex units of ISL. We provide report on classifiers in both spoken language and in SL. We report on ISL classifier handshapes from the literature. We examine ISL classifiers in terms of their behavior, based on the category of classifier they are associated with. We look to the SOI corpus to analyse classifier predicates in ISL. Finally we provide an account of how ISL classifiers may be represented within the lexicon in linguistically motivated computational terms. We utilise our newly defined Articulatory Structure Level to cater for ISL classifiers in terms of lexical meaning for ISL and the essential (computational) phonological parameters of an object as defined by the lexical item.

In chapter 7 we will further investigate ISL nouns with a view to articulating the linking system from the lexicon to include extended lexical representation into spatial visual syntax for ISL nouns. In this chapter we investigate the ISL noun phrase. We examine ISL nouns and the operators that may modify ISL nouns. We look to the literature to investigate the linguistics of ISL nominals. We begin by examining *locus* and what this term refers to in relation to SL. We examine anaphoric and deictic reference and the mechanics of pronominal reference in ISL. We look to the literature in terms of the behavior of adjectives and determiners with regard to ISL nominals. We examine Pustejovsky's GL theory of qualia and we consider its capabilities in terms of the representation of ISL nouns as lexical entries. We refer to RQ3, and address the question: How might lexical entries look for ISL nouns within the RRG lexicon? We posit a theory for lexical entries for ISL nominals and the layered structure of the noun phrase with regard to ISL using RRG as the underlying theory of grammar.

Chapter 8 provides an articulation of the linking system from the lexicon to include the Layered Structure of the Clause and the Layered Structure of the Noun Phrase

using RRG + Sign_A as our theoretical framework. This chapter addresses RQ 3. We illustrate an account for the LSC and LSNP by provision of both an operator and constituent projection within our functional model of grammar, RRG, the theoretical framework utilised within this body of research. We provide evidence to support RQ3 and our hypothesis in relation to lexical entries for ISL verbs, ISL classifiers and ISL nouns. We demonstrate that our linguistically motivated computational framework model has applicability to the LSC and also to the LSNP by illustrating these in terms of RRG constituent projections and operator projections for simple ISL sentences.

Chapter 9 This chapter addresses RQ4 by providing an account of the architecture of the RRG lexicon for ISL. We propose an architecture capable of accounting for the morphemes and lexemes of ISL within our proposed linguistically motivated computational framework. We propose a morpheme store and a lexeme repository to cater for ISL morphemes and ISL lexemes respectively. We use the context of an utterance to decipher whether an item should be placed within the morpheme store or within the lexeme repository of the Sign_A framework architecture. An item may exist within the morpheme store and also exist within the lexeme repository depending on their context within any given sentence. ISL morphemes, which demonstrate grammatical function, but lack any conceptual meaning will be placed within a morpheme store, while ISL lexemes or those morphemes that function in grammatical terms while also exhibiting conceptual meaning will reside within a lexeme repository.

2. The Linguistics of Irish Sign Language

2.1 Introduction

This chapter provides an account of SL, more specifically ISL, as a naturally occurring indigenous language of the Deaf community, with no written or aural form. As a language, ISL presents itself as being equally as rich and complex as any spoken language. Linguistic theory, which was developed in terms of spoken language, is challenged in providing an account for the very unique and interesting linguistic phenomena presented by SLs worldwide. It is the mode of communication of ISL, which is visual gestural in nature that contributes to the interesting challenges involved in providing an account of language in terms of linguistics.

This chapter provides an overview of the literature on SLs and broadly prepares to address research question RQ1: *To what extent can RRG account successfully for ISL sentence structure?* We introduce SLs as entirely complete and very rich independent languages, while providing an account of their evolution. We provide a detailed linguistic account of SL in terms of phonetics and phonology, morphology and syntax. We look to ISL, the indigenous language of the Deaf community in Ireland, which is the language of primary focus in this dissertation. Providing an account of how a sentence is constructed in ISL in linguistic terms allows us to understand the underlying linguistic complexities of the language and therefore contributes to the identification of the linguistic phenomena pertinent to ISL. This will impact our research in terms of the development of a linguistically motivated computational framework.

2.2 What is Sign Language?

SL is used worldwide by deaf people as a form of communication with each other and with those that hear. It 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). SL is heavily reliant on gesture and facial expression, which play a very important role in the expression of meaning. It is described as a natural

language. It was not consciously invented by anyone, but was developed spontaneously by deaf people and passed down without instruction from one deaf generation to the next (Sandler and Lillo-Martin, 2001).

In terms of production, signed languages 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). Communication occurs using a visual-gestural modality, encompassing manual and non-manual gestures. SL signs use visual imagery to convey ideas instead of single words. Manual gestures make use of hand forms, hand locations, hand movements and orientations of the palm. Non-manual gestures include the use of eye gaze, facial expression, head and upper body movements. Both manual and non-manual gestures may be articulated simultaneously to produce a valid understanding and interpretation of the SL.

Deaf communities have their own culture, with their own values and their own language. This makes them a minority group, both culturally and linguistically [About the Deaf Community - Sign Language Interpreting Services].

2.3 Evolution of Sign Language

Knowledge of SL use among deaf people dates back at least 2,000 years in Western civilisations. McBurney (2012) cites that some of the earliest documentation of SL surfaces in a series of Egyptian texts dating to approximately 1200 BC. Moving forward in time the writings of Greek philosopher Aristotle were interpreted as characterising deaf individuals as “senseless and incapable of reason,” and “no better than the animals of the forest and unteachable” (Hodgson, 1954, 62). These sentiments formed the early perceptions of hearing individuals with regard to members of deaf communities and of SL.

In the 16th century Aristotle's views on deafness were challenged by Gerolamo Cardano, an Italian physician and mathematician and the father of a deaf son. Cardano recognised that deafness did not preclude learning and education and he argued that deaf people could learn to read and write, and that human thoughts could be manifested either through spoken words or manual gestures (Radutzky,

1993). Around the mid 16th century, the Benedictine monk Pedro Ponce de León (widely cited as the first teacher of deaf children) set up a school for deaf children at the San Salvador Monastery in Oña, Spain.

One of the most important developments that led to the growth of natural SLs was the establishment of public schools for deaf children, where deaf children were brought together and SL was allowed to flourish. The first public school for deaf children was founded by the Abbé Charles-Michel de l'Epée in Paris, France in the early 1760s (McBurney, 2012).

2.3.1 Evolution of Irish Sign Language

The first recorded school for the deaf in Ireland was established in 1816. Initially, schools in Ireland for the education of deaf children were predominantly Protestant. The Dominican sisters set up a small Catholic school for girls in Cabra, Dublin, in 1846. Since the nuns who taught in the school were trained in France, (Matthews, 1996b) the female version of ISL was developed from an adaptation of French Sign Language (LSF) and an adaptation of BSL, which was used in the protestant schools prior to the establishment of St. Mary's school in 1846 (Leeson and Saeed, 2012). Modern ISL is also influenced by the English language. The nuns that taught at the all girls school attempted to modify the form of French mapping it onto the grammar of English which enabled them to sign in English (Leeson and Saeed, 2012).

St. Joseph's school for deaf boys was established in Cabra in 1857. The Christian Brothers used the same signing system as was used in the girls school in Cabra, however, the signs were altered drawing from American Sign Language (ASL) in order to make the language more masculine and suitable for boys (Crean, 1997; Leeson and Grehan, 2004). This adaptation coupled with the isolation of girls from boys allowed for the development of a significant gendered generational variant in ISL (LeMaster, 1990; Leeson and Saeed, 2012). While gendered signing still remains within the language, it is much less prevalent now amongst younger signer's than those who are aged 70+ (Fitzgerald, 2014; Leeson and Saeed, 2012).

2.3.2 Evolution of Sign Language Linguistics

The earliest linguistic analysis of SL was undertaken by Tervoort in his PhD dissertation work on Sign Language of the Netherlands (NGT) (Tervoort, 1953). Following on from this in 1960, William C. Stokoe Jr., a Professor of English at Gallaudet University, Washington DC, the only college for the deaf in the world, published his linguistic analysis of ASL. From the 1960s onwards, linguistic research of signed languages established that the gestures previously thought to be mime or primitive, a limited language at best, formed a natural language (Stokoe, 1960). Stokoe works formed a solid base for what was to become a new field of research: SL Linguistics. It was established that the signs used in different Deaf communities were different and mutually unintelligible: different SLs were acknowledged. It became clear also that signed languages make use of the manual-visual modality, while spoken languages make use of the auditive-oral modality (Schuit, 2007).

2.4 Irish Sign Language Phonetics and Phonology

ISL is the indigeneous language of the Irish Deaf community and is the first language of Deaf people in Ireland (Murtagh, 2011c). It is a visual, spatial language, with its own distinct grammar. ISL is not only a language of the hands, but also of the face and body. In both modality and linguistic terms, ISL is very different to spoken English or Irish. “While ISL is used by approximately 5,000 Irish deaf people, it is estimated that some 50,000 people also know and use the language, to a greater or lesser extent” (Leeson, 2001). ISL can be described as a minority language and therefore there is currently no linguistically motivated computational framework in place to sufficiently describe its architecture.

2.4.1 The Handshapes of ISL

O’Baoill and Matthews (2000: 36), describe how signs are formed within ISL by applying a set of phonological rules to a combination of handshapes and also how

“identification of these handshapes and permissible combinations (noting that alteration of a single aspect provides the potential for expansion to the lexicon) provides us with an understanding of the

building blocks of the formation of signs” (O’ Baoill and Matthews, 2000: 36).

Figure 2.2, taken from O’ Baoill and Matthews (2000), indicates the 66 different handshapes that are utilised within ISL in the formation of signed vocabulary. More recently, Matthews (2005) suggests 79 base handshapes exist within ISL.

Studies have revealed a high correlation between ease of articulation in handshapes and frequency of occurrence. Less complicated or unmarked handshapes tend to occur more often than more intricate or marked handshapes (O’ Baoill and Matthews, 2000). This phenomenon is has also been identified in BSL (Sutton-Spence and Woll, 1999; Orfanidou et al., 2009) and ASL (Brentari, 2010; Grosvald et al., 2012). Figure 2.1 taken from O’ Baoill and Matthews (ibid.), categorises some of the more frequent handshapes of ISL, unmarked and marked. Figure 2.2 illustrates the 66 handshapes of ISL initially identified by O’ Baoill and Matthews (2000).

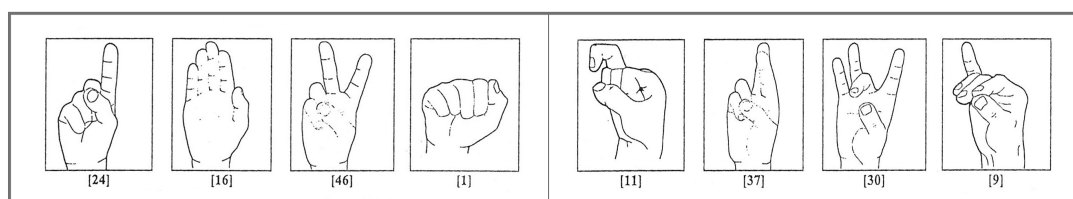


Figure 2.1 Unmarked and marked handshapes of ISL, O’ Baoill and Matthews (2000: 35)



Figure 2.2 The handshapes of ISL, O’Baill and Matthews (2000: 36-39)

2.4.2 The Signing Space

The signing space or gestural space (Rathmann and Mathur, 2002) is the space within which all signs must be articulated. The signing space usually extends from the waist outwards and includes the shoulders and the face. A diagram of signing space, taken from O’Baill and Matthews (2000) is shown in Figure 2.3.

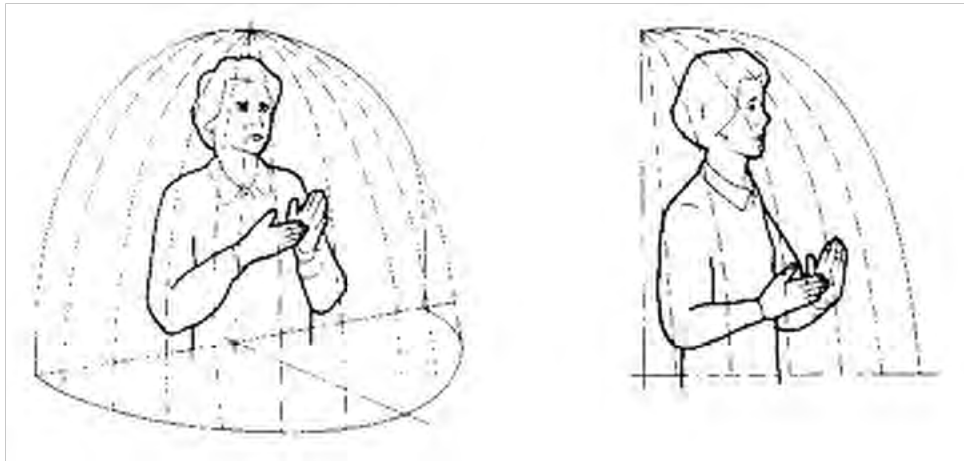


Figure 2.3 ISL signing space, O'Baoill and Matthews (2000: 40)

Neutral space is the space immediately in front of the signer and close to the signer's body. It encompasses the area from the head to the waist and extends the width of the signer's body. O'Baoill and Matthews (2000: 40) define neutral space as the space that is used when producing the citation form of an item and take the view that neutral space generally does not act as a referent for particular or special meaning. Leeson and Saeed (2012) on the other hand, argue that the signer's perspective is privileged and that items presented in 'canonical' locus or 'c' (Engberg-Pederson, 1993) are in focus. Marshall and Sáfár (2004: 190-191) outline the importance of location with regard to BSL MF where research has found that:

“some nominals can be signed at specific positions in signing space and these locations then have syntactic significance. Nominals which cannot be located in this way can be positioned in signing space by indexing a particular location after the sign. Nominals can be referred to anaphorically by inclusion of classifier handshapes within manipulator verbs. Directional verbs must be syntactically consistent with the locations of their subject and object in 3D space. Verbs exhibit syntactic agreement for number with their arguments and finally particular positions in signing space can be populated by more than one object or person, though typically these can be distinguished by different classifier handshapes.”

Liddell (1995) bases his approach to defining signing space on the work of Fauconnier (1985). Liddell (ibid.) provides three types of space. *Real space*, which defines a person's perception of the current environment, *surrogate*

space, is used to allow reference to entities that are not present. Using surrogate space, signer's can refer to these entities as if they were present. Entities within surrogate space are referred to as *surrogates*. Finally Liddell (ibid.) refers to *token space*. Token space refers to the locus in space where an entity or an index has been established. The entity can be referred to by then pointing to the position it was initially established within.

2.4.3 The Signs of ISL

According to O'Baoill and Matthews (2000) the signs of ISL can be divided into eight different categories according to the manner and mode of production. This work builds on previous work carried out by Brennan et al. (1984). The categories defined capture the articulatory generality of how manual signs are presented. Their description is based on the parameters listed in example 2.1, which relates mostly to whether a signer uses one or two hands in the articulation of a particular sign.

Example 2.1 (O'Baoill and Matthews, 2000: 42-45)

- a) One-handed signs, including body or near body contact during articulation.
- b) One-handed signs, where the sign is articulated in free space without any body contact.
- c) Two-handed signs having identical shape, where the hands touch during the articulation of the sign in space.
- d) Two-handed signs having identical shape, where the hands move in symmetry but without any contact taking place during the articulation of the sign in space.
- e) Two-handed signs having identical shape, where the hands perform a similar action and come in contact with the body.
- f) Two-handed signs having identical shape, where the hands are in contact during articulation, however, using one dominant articulator and one passive articulator.
- g) Two-handed signs showing a different shape, each hand having an active articulator and having equal importance.
- h) Two-handed signs showing a different shape, where the dominant hand (depending on whether the signer is left-handed or right-handed) is the active articulator and the other hand is the subordinate or passive articulator.

2.4.4 The Non-Manual Features of ISL

NMFs or markers in signed languages refer to those meaningful units of the visual-gestural language, which are used to convey additional information to the meaning being expressed by manual handshapes. The existence of NMFs within signed languages has been well documented by researchers, including Liddell (1980), Nolan (1993), Coerts (1990), Bellugi and Klima (1990), Baker and Padden (1978b). NMFs consist of various facial expressions such as eyebrow movement, movement of the eyes, mouth patterns, blowing of the cheeks and also include head tilting and shoulder movement. While NMFs are normally accompanied by a signed lexical item, they can be used to communicate meaning independent to manual accompaniment.

Within ISL, NMFs are used to express various emotions. They are also used to modulate or intensify the content of the information. In this sense NMFs function as intensifiers. The use of NMFs to express various syntactic properties is an identifying feature of SLs and ISL is no exception to this. O'Baoill and Matthews (2000) point out that NMFs function as both morphological and syntactic markers in ISL. Example 2.2 includes all of the relevant functions provided by ISL NMFs. Table 2.1 provides a listing of articulatory descriptors for NMFs in ISL.

Example 2.2 (O'Baoill and Matthews, 2000: 168-169)

- a) To show the degrees of emotion
- b) To denote intensification or modulation
- c) To distinguish declarative or interrogative sentences
- d) To denote negation
- e) To define topic or comment structures
- f) To indicate conditional clauses
- g) To show sarcasm

Table 2.1 ISL articulatory descriptors for non manual features, Leeson and Saeed (2012: 80)

FEATURE	ANNOTATION
Headnod	Headnod
Headshake	Headshake
Headtilt	TILT+[direction of tilt]
Headturn	TURN+[direction of turn]
Chin to shoulder	cs
Brows raised	Raised
Brows furrowed	Furrowed
Eyes wide	WD
Eyes squinted	SQ
Eyeblink	//
Eyes closed	CLOSED
Eyes averted	+ [locus of gaze]
Cheeks: Sucked in Puffed out	in puffed
<i>Lips:</i> closed open round forward stretched	closed open round forward stretched
<i>Air:</i> in out	in out
<i>Mouth corners:</i> up down	corners up corners down
<i>Tongue position:</i> in/out	10% out of the mouth 30% out of the mouth 60% out of the mouth 100% out of the mouth
<i>Tongue shape:</i> pointed relaxed	pointed relaxed
<i>Teeth:</i> Labiodental up Labiodental down	labiodental up labiodental down

2.4.4.1 Mouthings and Mouth Gestures

There has been a substantial amount of research carried out in the area of mouthing and mouth gesture in ISL. Mohr (2014) provides an empirical study of ISL mouth actions. Fitzgerald (2014) provides a cognitive account of mouthings and mouth

gestures in ISL. According to Leeson and Saeed (2012), within ISL use of mouthings and mouth gestures is interrelated and displays gendered-generational associations. *Mouthings* can be described as being derived from spoken language and show evidence of contact between English and ISL. They have been found to serve as the basis for minimal pair formation in ISL. *Mouth gestures*, which can be described as mouth patterns not derived from spoken language, also serve to create minimal pairs in ISL. Mohr-Militzer (2011) (see also Mohr 2014) found that there are considerable differences in mouthing in male and female signer's across age ranges. Within ISL, women tend to make greater use of mouthing than men. It has also been found that amongst men, older men make very little use of mouthing. Figure 2.4, taken from Leeson and Saeed (2012), shows mouth actions (combined) used by ISL signer's aged 55 and above.

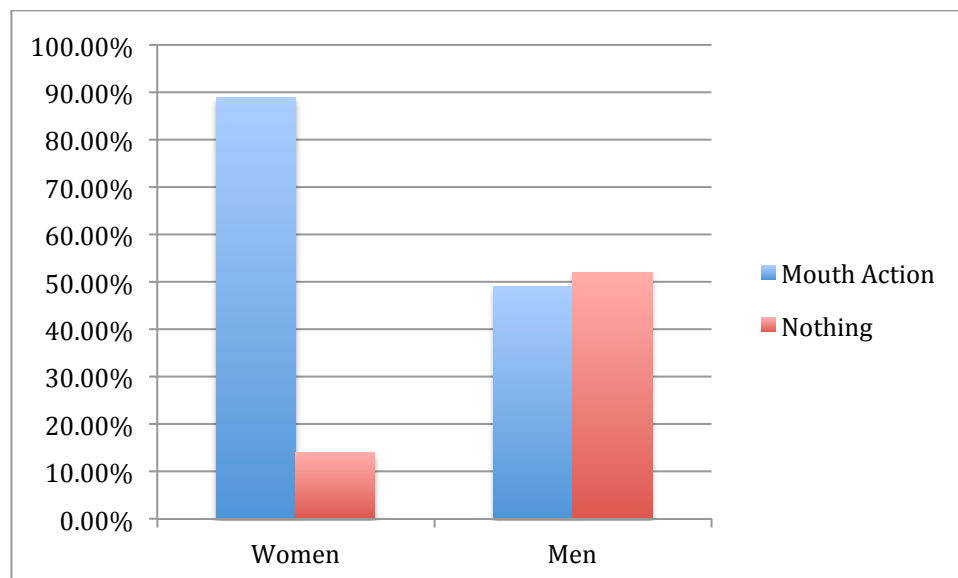


Figure 2.4 Mouth actions (combined) used by ISL signer's aged 55 years and above, Leeson and Saeed (2012: 84)

2.4.5 Manual Features in ISL

William Stokoe (1960) identified the various parameters, which are relevant for the analysis of SL. He suggested that the articulation of a sign encompassed three different parameters. A designator, which was used to refer to the specific combination of hand configuration, abbreviated to *dez*. A tabulation, used to refer to the location of the hands and abbreviated to *tab*, and a *signation* used to refer to the

movement of the hands and abbreviated to *sig*. *Dez*, *tab* and *sig* were examples of what he called *cheremes*, the signed equivalent of phonemes.

Later research refers to these parameters of SL as *handshape*, *location* and *movement*. (Sutton-Spence & Woll (1999) : Valli & Lucas (1995)). Battison (1978) claimed that a fourth parameter is necessary in order to be able to fully transcribe signs. This fourth parameter is called *orientation*, and denotes the orientation of the hands and fingers during the articulation of the sign. The abbreviation of orientation is *ori*.

2.4.5.1 Handshape

We have seen that section 2.4.1 provides characteristic handshapes of ISL taken from O'Baoill and Matthews (2000). While the HamNoSys inventory of handshapes has been adopted internationally by many phonologists, Thorvaldsdottir (2010) identifies that this international database of handshapes doesn't fully capture the range of ISL-specific handshapes that exist. An example of this taken from Thorvaldsdottir (ibid.) is shown in Figure 2.5.



Figure 2.5 ISL handshape not found in HamNoSys, Thorvaldsdottir (2010: 236)

Another issue with the use of an international inventory of handshapes is that there are phonetic variants within ISL that are not represented in the international database. An example of this, identified by Thorvaldsdottir (2010) is provided in Figure 2.6.



Figure 2.6 Handshape not noted before in ISL handshape but used in signs like BOY, Thorvaldsdottir, (2010: 236)

An example of allophonic variation in ISL is illustrated in Figure 2.7 and 2.8. These examples from the Signs of Ireland (SOI) corpus were identified by Leeson and Saeed (2012: 76, Example 4.8). Figure 2.7 shows the citation form for BOY in ISL articulated with four selected fingers. Figure 2.8 shows the variation of the sign BOY in ISL articulated with one selected finger.

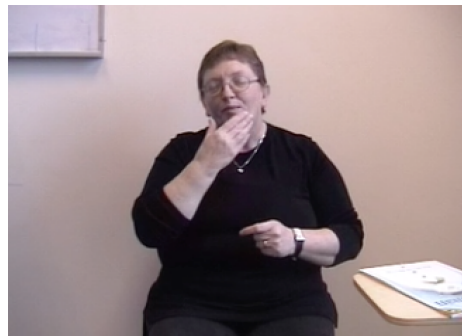


Figure 2.7 Citation form for BOY: articulated with four selected fingers Noleen (03) Personal Stories (Dublin), Leeson and Saeed (2012: 76, Example 4.8a)

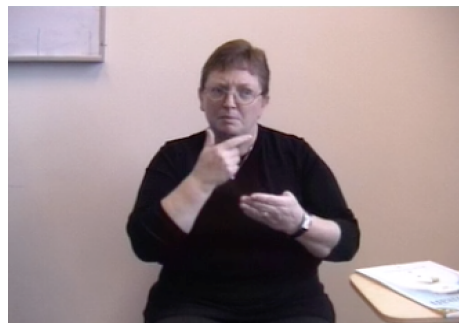


Figure 2.8 Variation of the form for BOY: articulated with one selected finger Noleen (03) Personal Stories (Dublin), Leeson and Saeed (2012: 76, Example 4.8b)

2.4.5.2 Location

Brennan et al., (1984), identify five different spatial locations when describing BSL: the head (and neck), the arms, the trunk, the hands and the area in front of the signer's body. Each of these locations can then be further divided into individual tabs. In BSL, the head, ears, nose and mouth are all sub divisions of the head and seen as separate tabs (Leeson and Saeed, 2012). Minimal pairs in ISL can be identified on the basis of tab difference. Matthews (1996a) gives the ISL examples of MY and STUPID as an example of minimal pairs, where the feature that changes meaning is location. MY has the signer's chest as a tab, whereas STUPID has the forehead as a tab.

2.4.5.3 Movement

Leeson and Saeed (2012) use the feature analysis of movement proposed by Friedman (1977), to describe movement in ISL. This feature analysis of movement includes four fundamental features: *interaction*, *contact*, *direction* and *manner*. *Interaction* describes whether one or both hands move and if they perform the same movement or interact with each other. *Contact* describes whether hands make contact with the body and the type of contact. *Direction* describes movement in space in terms of three-dimensional space and *manner* describes the type of movement in terms of 'macro' for example an entire arm and 'micro' for example a finger joint on the hand. Brentari (1988) defines movement in terms of local or path movement, where local movement refers to the movements of fingers, knuckles or wrists and they may cause a change in orientation or handshape, whereas, path movement refers to movement caused by the elbow or shoulder and result in a change in location.

2.4.5.4 Orientation

Matthews (1996a), describes how within ISL, similar to other sign languages (notably ASL and BSL) orientation can also be described as a defining factor for differentiation between minimal pairs. An example of this within ISL can be seen in

Figure 2.9 and 2.10, which show how the articulation for ‘blood’ and for ‘lesson’ in ISL are differentiated only by the orientation of the hands.



Figure 2.9 Articulation of BLOOD in ISL, O’Baioill and Matthews (2000: 49)



Figure 2.10 Articulation of LESSON in ISL, O’Baioill and Matthews (2000: 49)

2.5 Irish Sign Language Morphology

2.5.1 Words

Signs in SL are situated at an equivalent level of organisation as words in spoken language and these units have psychological and cultural validity for their users (Zeshan, 2002). Meir (2012) proposes that SLs have *words*, which can be defined as “conventionalised units of form-meaning correspondence, like spoken languages”. Brennan (1994) concludes that the *sign* in SL clearly functions as the linguistic unit we know as the *word*. Following Brennan (1994), Leeson and Saeed propose that *signs* are equivalent to *words* in spoken language in terms of grammatical role. Stokoe (1960) described *signs* as being much more simultaneously organised than

words. Signs are not holistic units, but are made up of specific formational units: hand configuration, movement, and location (Stokoe, 1960).

2.5.1.1 Polysemous signs

Keeping in mind that SLs are indigenous languages of their own community and country of origin and that SLs evolved naturally, it is important to consider whether in a similar vein to spoken languages, the meaning of signs can change over time, leading to cases of polysemy (O’Grady et al., 2000). “The phenomenon of multiple related meanings within a single lexeme is known as polysemy” (Jurafsky and Martin, 2014: 595). Polysemy is of course a critical issue within the realm of natural language processing, since it raises the very challenging problem of word sense ambiguity. ‘Word sense disambiguation is the ability to computationally determine which sense of a word (having multiple meanings) is activated by its use in a particular context’ (Husain and Rizwan Beg, 2013: 1162). Lexical ambiguity occurs when a word has multiple meanings. Example 2.3 provides an example of lexical polysemy in spoken English, where *duck* may be categorised in grammatical terms as either verbal or nominal.

Example 2.3

- a) I made her duck

The verbal categorisation would reflect a downward movement where the participant makes somebody (her) duck downwards. The nominal categorisation, on the other hand, would refer to the participant preparing food (duck) for somebody (her). According to Husain and Rizwan Beg (2013: 1162), various other types of ambiguity also occur, including structural or syntactic, semantic, pragmatic and also vagueness. An example of structural or syntactic ambiguity in spoken English can be seen in Example 2.4, where the telescope may be categorised as an instrument of the actor (the man), or as an item possessed by the participant ‘seeing’.

Example 2.4

- a) I saw the man with the telescope

Polysemous signs do exist within ISL. Some examples of these include the sign for SINGLE/SOMEONE, AFFECT/ANNOY, WORRY/CONCERN, WAG-FINGER (give out)/CAUTION. If we take the example of the sign for WORRY, which is identical to the sign for CONCERN and analyse this further we can define WORRY in grammatical terms as an experiencer verb and is therefore verbal in nature, whereas CONCERN can be defined as a nominal. Example 2.5 below provides an example of WORRY in ISL taken from O'Donnell (1996). McDonnell (ibid.) identifies WORRY as a plain verb denoting an emotional state.

Example 2.5

A-l-a-n WORRY LITTLE
Alan was somewhat worried
(McDonnell, 2006: 134, Example 4.68)

CONCERN on the other hand can be defined as a noun in Example 2.6.

Example 2.6

INDEX+c UNDERSTAND INDEX+f CONCERN
I understand your concern
(Elicited example)

Briefly looking across these named pairs it would appear that ISL presents the phenomenon of lexical polysemy, where the same sign may be used to represent differing lexemes. Polysemy within the examples provided appears to present itself at the lexical level. With regard to our computational framework we must take this into consideration as we approach the development of our lexicon architecture. Separate noun and verb lexicons will reside within the architecture and definition allowing for the representation of both the noun and verb sense of the lexeme must be developed to cater for this linguistic phenomenon.

As polysemy is a critical issue within the domain of natural language processing, future work on polysemous signs and lexical polysemy within ISL and also investigation into an approach to address this phenomenon within our linguistically motivated framework will be necessary. Steps involved in this future work will include defining the distinct senses a lexeme has, defining how these sense are related and also defining how they can be reliably distinguished.

2.5.2 Phonemes and Morphemes

There is an important difference between *signs* and *words* with regard to iconicity. *Signs* are much better at iconically depicting the concepts that they denote (Taub, 2001). Cuxac (1999) proposes that SL discourse is shaped at every level by iconicity and as a result a sign can be used to represent physical aspects of a referent, a spatial location within three-dimensional space, motion patterns and also temporal reference. Other researchers have made similar claims with regard to iconicity (Taub, 2001; Klima and Bellugi, 1979; Cuxac and Sallandre, 2007).

Meir (2012) describes how iconic signs present a challenge to the traditional division between phonemes and morphemes. Phonemes may be meaning-bearing and not meaningless within SL. Johnston and Schembri (1999) propose the term ‘phonomorpheme’ as a descriptor for the dual nature of iconic signs. This term is deemed a more suitable descriptor as iconic signs function simultaneously as both phonemes and morphemes, serving as the basic formational building blocks and at the same time as minimal meaning-bearing units (Meir, 2012).

Leeson and Saeed (2012) discuss the articulation of the ISL verb GIVE-TO, which supports Meir’s discussion on phonomorphemes. Figure 2.11 depicts the articulation of the verb GIVE-TO. In this figure ‘someone’ (named\unnamed) GIVES-TO the ‘signer’ and in figure 2.12 this is reversed and the ‘signer’ GIVES-TO to ‘someone’ (named\unnamed). Leeson and Saeed (2012: 92, example 5.1) describe how the signer marks the onset of the verb at the forward side right of his signing frame and this is referred to as the +sr locus. The offset of the verb is at the signer’s torso, which is designated the canonical locus or ‘c’ (Engberg-Pedersen, 1993).

Within the articulation sr+GIVE-TO+c, +sr is needed to complete the sign, therefore, it is considered a phoneme. However, the *locus* +sr also carries meaning as ‘someone’ (named\unnamed) who is co-referential with *locus* ‘c’ gives something to the *signer*. Leeson and Saeed (ibid.) also note that if the onset and offset points of the verb are reversed to articulate c+GIVE-To+sr, then the meaning of the sign would change to represent the *signer* giving to the person co-referential with the *locus* ‘+sr’.



Figure 2.11 sr + GIVE-TO + c Fergus D. (06) personal Stories (Dublin), Leeson and Saeed (2012: 92, Example 5.1a)



Figure 2.12 c + GIVE-TO + sr Fergus D. (06) personal Stories (Dublin), Leeson and Saeed (2012: 92, Example 5.1b)

Figure 2.13 depicts the articulation of the verb ASK in ASL.



Figure 2.13 ¹Forms of ASK in ASL, Mathur and Rathmann (2012: 137)

¹ The form on the left corresponds to I ASK YOU. The form on the right corresponds to YOU ASK ME (Mathur and Rathmann, 2012: 137).

The only difference between these two forms lies in the orientation of the hand and the direction of movement: the form on the left is oriented and moves towards an area to the signer's left, while the form on the right is oriented and moves towards the signer's chest. This phenomenon is well illustrated in many SLs (Mathur and Rathmann, 2012). The change in direction of movement and also orientation has been described by researchers as verb agreement in SL. The change in the two forms corresponds to a change in meaning often marked in spoken languages by person agreement with the subject and object (Mathur and Rathmann, 2012).

2.5.3 Locus

A locus in SL refers to a location in space in which a specific entity has been established (Liddell, 2012). The signer can establish an entity by articulating a lexical sign at a specific location in space. A signer can also produce a sign and then direct eyegaze or point to a location in space (Leeson and Saeed, 2012). Once established an entity can be referred to later in the discourse.

Liddell (1990) describes how locus can also be situated on the signer's body. The location on the body that the locus is situated has been found to have phonological significance. Liddell refers to this as having an articulatory function. Liddell further describes a locus that can have a three dimensional function. In this situation the locus stands for a spatial location. The signing space can be described as a stage on which entities are located. Progressing from here, within the literature Liddell (2003) refers to locus and space within SL in terms of surrogate space and token space. This is based on the Mental Spaces Theory (Fauconnier, 1994).

Signer's use classifier predicates to represent real world entities and entities are located in relation to each other as they are in the real world (Leeson and Saeed, 2012). Sutton-Spence and Woll (1999) refer to this as topographical space. Leeson and Saeed (2012) describe how entities can also be assigned a locus on the fingertips, with each fingertip then being activated as a locus that is co-referential with that entity.

2.5.4 Noun Plurals

ISL signs are inflected for grammatical information in similar ways to spoken language. While plural in English nouns is often marked by suffixation of a bound morpheme, for example –s in singular/plural pairs like girl/girls, Figure 2.14 identified by Leeson and Saeed (2012) and taken from the SOI corpus, shows the sign for HOUSE, which has been repeated three times HOUSE+++. This reduplication communicates the meaning ‘houses’ in ISL.



**Figure 2.14 ISL Reduplication to mark noun plurals: HOUSE+++ ('houses')
Geraldine (20) Personal Stories (Dublin), Leeson and Saeed (2012: 96, Example 5.3)**

2.5.5 Irish Sign Language Verbs

Verb classification within SL is traditionally described according to Padden's classical tripartite classification of verbs based on American Sign Language (ASL) (Padden, 1988). The original theory has subsequently been re-visited, but Padden's observation, which was in most cases universally accepted, is that SL verbs fall into one of three categories: *plain* verbs, *spatial* verbs and *agreeing* verbs. Padden initially named agreeing verbs as inflecting verbs but subsequently changed the term to agreeing verb.

The verb classes can be differentiated between depending upon the arguments that they encode. Not all SL verbs use a phonological shift in orientation or direction of movement to reflect a change semantically. According to Padden (1988) *Plain verbs* are verbs that constitute the default semantic class. 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. *Agreeing verbs*, which agree with the subject and/or object, are a class of verb that denote transfer and are said to encode the syntactic role of the arguments, as well as their person and number features, by the direction of the movement of the hands and the orientation of the palms. Agreeing verb affixes show agreement with person or location. *Spatial verbs* are verbs that denote motion and location in space. Spatial verbs encode the locations of locative arguments (the source and the goal), based on the direction of movement of the hands. The shape of the path movement the hands are tracing is said to often depict the shape of the path that an object traverses in space. Figure 2.15 illustrates the three verb categories proposed by Padden (1988) in the tripartite theory of verbs.

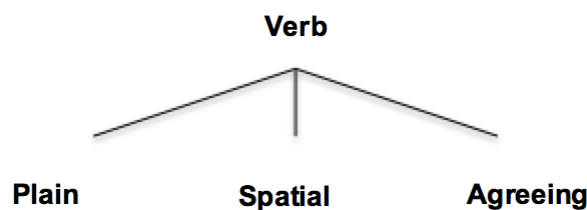


Figure 2.15 Tripartite verb classes, based on Padden (1988)

Meir et al. (2007: 366) subsequently re-visited the tripartite theory to look at the role the body plays in different verb classes and as a revision proposes that “The signer’s body is not merely a formal location for the articulation of signs, but may, in principle, be associated with a particular meaning or a particular function.” Meir et al. (ibid.) assume the view of Taub (2001) and Russo (2004) with regard to *iconicity*, where it refers to the regular mapping between formational units of an expression and components. Meir et al. (ibid.: 367) provide an example of EAT as an iconic verb, and provide iconic mapping for the verb using both Israeli Sign Language (Israeli SL) and ASL as an example. In iconic or partially iconic verbs articulated on the body (body-anchored verbs), the body represents the subject argument. In summary this revision identifies *plain verbs* and in particular *body-anchored plain verbs* as the set of verbs in which the body is the subject and the category of grammatical person is not encoded. In *agreement verbs* in the inflected

form, the body is 1st person, locations in signing space are associated with non-1st person and the direction of movement of the hands and the facing of the hands encode syntactic and semantic roles of the arguments. *Spatial verbs*, including classifier constructions, are those with beginning and end points determined by spatial referents, that is, by their actual or designated locations in a spatial array, and not by the syntactic arguments of subject or object. The locations encoded by verbs in this class are interpreted analogically and literally, and not as representing grammatical arguments (Padden, 1998, Meir et al., 2007). Table 2.2 taken from Meir et al. (2007) provides a summary of the re-visited verb classification for SL.

Table 2.2 Tripartite verb classes redefined, Meir et al. (2007: 374)

Verb Class	Body	Hands	Space
Plain verbs	Corresponds to subject	Do not encode properties of arguments	
Agreement verbs	1 st person	Encode syntactic and semantic roles of arguments	Non-1 st -person referents
Spatial verbs	Spatial reference point or not involved	Encode locative roles of arguments	Locations in space

Main verbs in ISL similar to other SLs are identified as belonging to one of three morphological classes: plain, agreement or spatial/classifier verbs (McDonnell, 1996). Figure 2.16 taken from McDonnell (2006: 109, Figure 3.14) provides an illustration of ISL verb classes and their respective sub-classes. McDonnell (ibid.) identifies that plain verbs in ISL do not take affixes, whereas agreement verbs take affixes, which mark for person or location, altering the form of the verb in different contexts. With regard to agreement verbs McDonnell (ibid.) identifies both person and locative agreement verbs, however, in relation to locative agreement verbs a separate distinction is made between locative verbs and classifier predicates of motion and location. Within this distinction classifier predicates present a hand configuration that provides both a morphological and a phonological function, whereas in relation to agreement and plain verbs hand configuration provides a phonological function only.

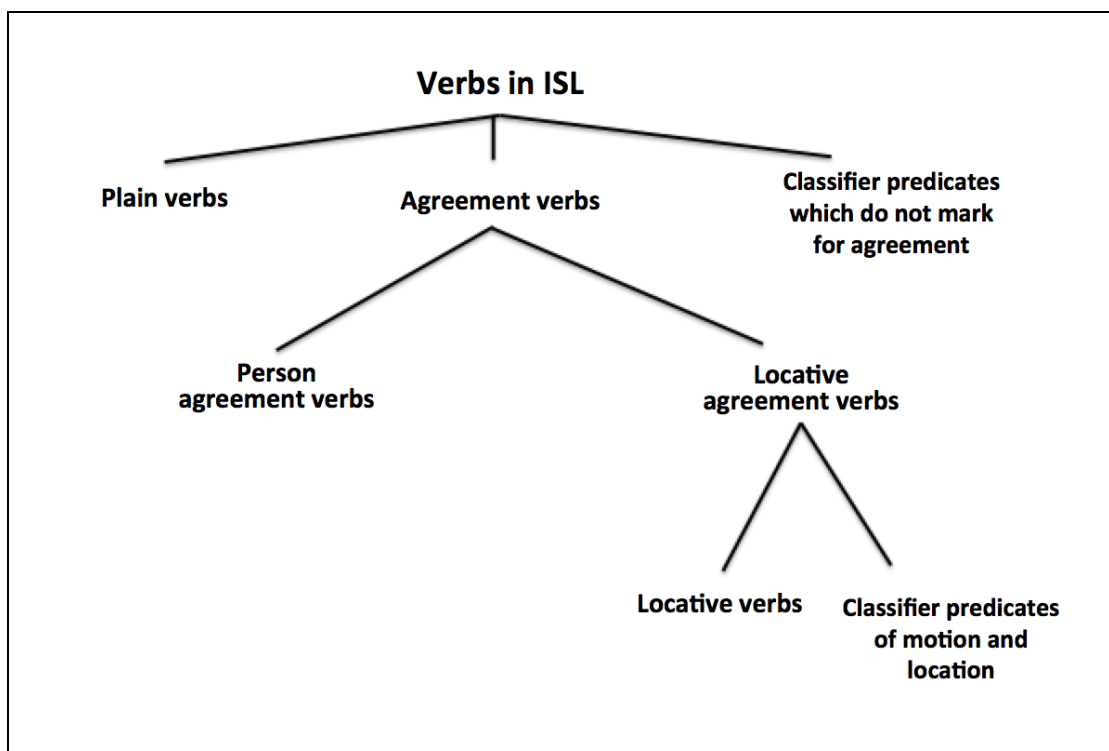


Figure 2.16 Categories of Verbs in Irish Sign Language, McDonnell (2006: 109, Figure 3.14)

Leeson and Saeed (2012) agree with McDonnell (1996) and the basic distinction in ISL between plain verbs, which are uninflected and do not take agreement affixes and agreement verbs, which show agreement with both person and location. Leeson and Saeed (ibid.) also identify that ISL agreement verbs may be further sub-divided into those that show *person agreement* with subject/actor or object/undergoer and those whose affixes are controlled by locations (*locative agreement*).

2.5.6 Classifier Predicates

Classifier predicates are well researched within the literature and can be observed in almost all SLs studied to date (Zwitserslood, 2012). They are represented phonologically by a specific handshape. Zwitserslood describes classifiers as generally considered to be morphemes with a non-specific meaning, which are expressed by particular configurations of the manual articulator and which represent entities by denoting salient characteristics. Liddell (2003:261) refers to classifiers as depicting verbs, which “in addition to their encoded meanings, also depict certain aspects of their meanings”. Schembri (2003) refers to classifier verbs in Australian Sign Language (Auslan) as polycomponential verbs of motion, location, handling and visual-geometric description. Schembri (2003) identifies this type of verb as

occurring in over thirty natural SLs. Morgan (2009) identifies, that with classifier verbs, the verbal argument (usually the object) is incorporated into the form of the verb, not as movement but rather as handshape, which stands for a class. Leeson and Saeed (2012) define ISL classifiers as a set of handshapes (sometimes with movement components) that provide a visual-geometric description of entities within a given SL, providing information about motion, location and handling. Emmorey (2003) refers to Supalla, (1982, 1986), when defining classifiers in ASL:

“Classifier constructions are complex predicates that express motion (e.g., “The car meandered up a hill”), position (e.g., “The bicycle is next to the tree”), stative-descriptive information (e.g., “It’s long and thin”), and handling information (e.g., “I picked up a spherical object”)”.

Supalla (1982) identifies classifiers as differing from plain, agreeing and spatial verbs in terms of the handshape functioning as a morpheme and a classifier. Zwitserlood (2012) provides an overview of the current status of SL classifiers in terms of the literature and concludes that although much work has been done in terms of classifiers and classifier constructions and many different claims and generalisations have been made resulting in various theories, there is still much controversy in this area of sign linguistics. Due to differing opinions among researchers, classifiers are still subject to much debate with respect to a variety of issues including their structure, naming and also the different the categories of classifiers, which have been identified. It seems that across the greater sign linguistics research community, these issues currently remain unresolved and further research is necessary on order to provide a solution to these outstanding problems. Further information on classifier verbs and the literature is included later in this research in chapter 6.

2.5.7 ISL Classifier Categories

The early study of SL classifiers was heavily influenced by the literature on spoken language classifiers. Allan (1977) divided spoken language classifiers into four distinct types, one of which was defined as a “predicate classifier language” (e.g. Navajo). Classifiers in SL were likened to this type. McDonnell (1996) and Leeson and Saeed (2012) follow Aikhenvald (2000) with regard to predicate classifiers,

where predicate classifiers are described as ‘morphemes associated with verbs that allow the speakers to classify the subjects or objects in relation, typically the shape, number or distribution of the entity concerned’ (Leeson and Saeed, 2012: 110).

McDonnell (1996) draws on the work of Brennan (1992) in categorising ISL classifier predicates. McDonnell (ibid.) identified four broad categories of classifier predicates for ISL. These are summarised in Table 2.3. The following sub-sections provide an overview of the classifier predicates of ISL, drawing from Leeson and Saeed (2012).

Table 2.3 ISL classifier categories, based on Leeson and Saeed (2012: 110)

Category	Description
Whole entity-CL stems	Includes hand configurations that refer to semantic size and shape, and instrumental categories
Extension-CL stems	Includes reference to tracing size and shape configurations
Handle entity-CL stems	Includes reference to handling and touch categories
Body-CL stems	Where the signer’s body functions in a way that is similar to the way that handshapes function in certain two-handed configurations.

2.5.7.1 Whole Entity-CL Stems

In these classifier stems, the hand configuration typically represents an entire entity. Leeson and Saeed (2012) describe how several subcategories of whole entity-CL stems have been identified within ISL. A semantic-CL stem refers to an entity in terms of its semantic features (for example, + animate). A size and shape-CL stem refers to an entity in terms of its shape (for example, square). McDonnell (1996) proposes that these types of stems can combine with the same types of movement in ISL such as MOVE, BE-LOCATED and EXIST. McDonnell (ibid.) identifies a multiple entity-CL handshape in ISL identifiable as ‘5-hand/s’ referring to the signer’s fingers being open and spread. This handshape refers to multiple entities as members of large groups and is an example of a classifier in ISL being used to quantify. These classifiers seem to correlate with the Whole Entity Classifier group, which has been identified for other SLs also, including Danish Sign Language (DTS) (Engberg-Pedersen, 1993) and ASL (Liddell and Johnson, 1987).

2.5.7.2 Extension-CL Stems

Extension-CL stems trace rather than represent entities that they refer to. These CL stems only combine with EXTENT movements.

2.5.7.3 Handle Entity-CL Stems

Leeson and Saeed (2012) refer to the use of handle entity-CL stems as indicating an animate actor. These entity-CL stems have handshapes that typically denote the configuration of the hand as it moves, touches or uses an object, or part of an object rather than the object as a whole.

2.5.7.4 Body-CL Stems

Leeson and Saeed (2012) refer to the use of this category in situations where the signer's body functions similar to the way that handshape functions in two-handed configurations. Typically the body classifier involves the body of the signer and is used as an independent articulator referring to a single animate entity, which is typically an individual.

2.5.8 Compounds

Leeson and Saeed (2012) define compounds as words that are made up of two or more free morphemes that can function as separate words within the language. Meir (2012), defines a compound as a word composed of two or more words and describes how compounding helps to expand the vocabulary of a language by using combinations of two or more words from the existing lexicon to create novel meanings.

2.5.8.1 ISL Compound Properties

Sequential compounding in ISL occurs when signs are articulated one after the other in sequence. The compound formation involves the use of free morphemes and the meaning of the compound is generally distinct from the meaning of the phrase. Leeson and Saeed (2012: 115) use the sign OLD_MOTHER in ISL, which means grandmother and not old mother to demonstrate this. They report that ISL compound signs (which are usually made up of two free morphemes) usually involve a location change, and sometimes a change of handshape will also occur.

Often in ISL, the first compound is a one handed sign. The transition process between the ISL elements in the compound is smoother than the usual transition between separate signs.

2.5.8.2 Constraints on Compound Formation in ISL

Leeson and Saeed (2012) identified that ISL compounds have both one and two-handed signs as the first morpheme, with the first sign in a compound often being articulated as a one handed sign. This is not in line with Wallin (1983), who identified that in Swedish Sign Language, in nearly all cases, the first sign is always a one handed sign. Leeson and Saeed found that the general principle for ISL is that the first component in a compound begins higher up in the signing space than the second component. Leeson and Saeed also found that loan-translation has occurred in ISL, where vocabulary has been borrowed from spoken language to influence ISL. An example used for ISL is SIT-ROOM translating to “sitting room”.

Leeson and Saeed (ibid.:121) identify that simultaneous compounding occurs when two separate free morphemes occur simultaneously. Within ISL the compound sign ‘TELEPHONE-TYPE’ translates to ‘minicom’. This is an example of simultaneous compounding where each morpheme is articulated on a separate hand at the same time in ISL. Similar to Brennan (1990, 1992) Leeson and Saeed (ibid.) identify that many of the signs in ISL that have been traditionally considered to be simultaneous compounds are made up of classifier handshapes and therefore, these signs do not satisfy the criteria set out for what defines compounding. Drawing from the SOI corpus in their analysis, Leeson and Saeed (ibid.: 121) provide PARACHUTE-JUMP as an example of a lexicalised simultaneous compound sign that falls into this category.

2.6 Irish Sign Language Syntax

2.6.1 Grammatical Categories of ISL

This section provides an overview of grammatical categories within ISL taken from Leeson and Saeed (2012), from whom the most up-to-date contribution on research in this area is provided.

2.6.1.1 Nouns

Leeson and Saeed report that within ISL nouns may be reduplicated as discussed in chapter 4. They also report that nouns may be modified by adjectives and also colour terms, with the adjective typically occurring pre-nominally, where the adjective generally precedes the noun. The following examples taken from Leeson and Saeed (2012) illustrate this.

Example 2.7

- a) THINK BIG HEAD
‘(I) thought (he was) big headed’
- b) MEAN BIG LADDER
‘meant the big ladder’
- c) BIG CELEBRATION
‘big celebration’
- d) STOP RED TRAFFIC LIGHT
‘(he) stopped at the red traffic light’

(Leeson and Saeed, 2012: 152, Example 7.2)

Leeson and Saeed report that the only adjectives found to occur post-nominally were those used to quantify size (BIG and SMALL). This is illustrated in the following example.

Example 2.8

- a) BUY SELF OWN SHOVEL SMALL-ONE
‘you had to buy your own small shovel’
- b) WHEN JASON SMALL
‘when jason was small’

(Leeson and Saeed, 2012: 153, Example 7.4)

Leeson and Saeed also report that when quantifiers and numerals are used as determiners the noun is not normally pluralised. This is illustrated in Example 2.9.

Example 2.9

- a) ALL BOY
‘all (the) boys’
- b) TWO MAN
‘the two men’

(Leeson and Saeed, 2012: 154)

2.6.1.2 Verbs

Similar to spoken language, ISL provides examples of transitive, intransitive and ditransitive main or lexical verbs. Main verbs in ISL can belong to one of three morphological classes: plain, agreement or classifier verbs.

Auxiliary or helping verbs are also found in ISL and stand in front of a main verb to convey distinctions of tense, modality and aspect. Leeson and Saeed (2012) refer to CAN, FINISH, NEED, MUST, SHOULD and WILL as ISL auxiliary verbs.

2.6.1.3 Pronouns

Pronouns in ISL map referents to locations. ISL makes use of both deictic and anaphoric pronouns. Leeson and Saeed (2012) report that the deictic use is reliant upon the physical presence of the referent in the context of communication. Deictic pronouns are formed using pointing signs and distinguish between the signer, addressee and other signer's based on their real-world location. With regard to glossing, first person is referred to as INDEX+c. YOU/HE/SHE (based on a previously established locus at a particular point in space) is referred to as INDEX+f.

Leeson and Saeed also identify lexical forms for WE, HE, THEY and WE, however these are used much less frequently than the index form. Plural non-first person forms are formed by moving the pointing sign through a horizontal arc in the direction of the referents. Inclusive first-person plural pronouns (WE/US) are formed by a downward pointing sign moved in an arc or circular motion between the signer and addressee (s). Where number is specified the index handshape is replaced by a numerical handshape while maintaining the circular motion.

Leeson and Saeed (2012) also provide an account of the anaphoric use of pronouns within ISL, where anaphoric reference is dependent on the prior establishment of nominal referents. A nominal is initially introduced and this is associated with a specific location in the signing space, which thereafter acts as a pronominal reference to the particular entity.

2.6.1.4 Adjectives

Adjectives and adverbs can be modulated to convey intensity and other qualities such as size. The following are examples of adjectives in ISL taken from Leeson and Saeed (2012).

Example 2.10

a) SHE ALWAYS HAPPY WITH ME

‘she is always happy with me’

b) EVENING VERY COLD

‘the evening was very cold’

(Leeson and Saeed, 2012: 159, Example 7.13)

Leeson and Saeed (2012) note that adjectives may occur as predicates in ISL without a linking or copula verb.

2.6.1.5 Prepositions

Prepositions such as *over*, *under*, *on*, *in* and *beside* are represented in ISL by the use of locations and spatial relations in the signing space, which are used to represent the real world. Findings from Leeson and Saeed (2012), identify that certain lexical items may be used in lieu of or in addition to spatially represented locative relationships.

2.6.2 Sentence Types in ISL

Leeson and Saeed (2012) identify various major sentence types in ISL. The basic sentence type is a declarative sentence used to make statements. This type of sentence does not make use markers (NMFs) like other sentence types in ISL. A second major sentence type in ISL is an interrogative sentence. This type of sentence uses NMFs such as movements of the signer’s head and body to form questions. One basic type of interrogative sentence provided by Leeson and Saeed (2012) is a polar or yes-no question. This sentence type is marked in ISL by the non-MFs of raised eyebrows, widened eyes and also head tilting forward. A third sentence type is content questions, also referred to as WH-questions in English grammatical literature.

Leeson and Saeed (2012) identify that ISL contains question words that are signed manually such as WHAT, WHO, WHERE, WHEN. These signs are typically (but not always) accompanied by a forward tilt of the head and also a lowering of the eyebrows. In some cases a narrowing of the eyes may also be included. Another major sentence type identified by Leeson and Saeed (2012) is the imperative, typically used to make commands or requests or also to make strong suggestions. Leeson and Saeed note that in ISL MUST and HAVE-TO frequently occur in this context.

2.6.3 Negation and Time

According to Leeson and Saeed (2012) there are two methods to produce negation in an ISL sentence. One method is to insert a negative word such as NOT, NEVER or NOTHING. The second method is by the simultaneous use of a non-manual sign throughout the clause. The non-manual sign used to denote negation is a head-shake or side-to-side movement of the head.

In chapter 5 we will provide a discussion in relation to tense, where it will be shown that tense is not marked morphologically on verbs in ISL. Leeson and Saeed (2012) identify one strategy to mark tense is by the use of time adverbials NOW, TOMORROW or YESTERDAY, where the main verb remains uninflected. Time references using this strategy may be deictic or anaphoric.

A second method identified by Leeson and Saeed (2012) is to use different areas of the signing space that express time distinctions. Points in time can be mapped onto various locations on a timeline, where the past is seen as extending backwards and the future extending forward.

2.6.4 Constituent Order and Simultaneity

Leeson and Saeed (2012: 168) identify that word order in ISL is determined by a number of interlocking principles. Two of the most important of these principles are topic-comment structure at the level of information structure and subject-verb-object order at the level of grammar. Leeson and Saeed (ibid.) identify that these two principles may provide the same order due to the fact that, “as in many

languages, the selection of subject and topic is influenced by similar principles of animacy, empathy and viewpoint”.

With regard to person *agreement verbs*, the verbal arguments represent a range of semantic roles that may be grouped into the two macro-roles of actor and undergoer (Foley and Van Valin, 1984). The actor role includes the roles of agent and experiencer and the undergoer includes the roles of patient, recipient and stimulus. Leeson and Saeed (2012) identify the default mapping between semantic and grammatical roles in ISL transitive clauses as the actor role to be the subject and the undergoer role to be the object. This is realised in the order of subject-verb-object.

Example 2.11

GIRL WATCH TV

“The girls watched TV”

(Leeson and Saeed, 2012: 168, Example 7.25)

The process of using two-handed signs and employing simultaneous constructions in ISL allows information about constituents to be distributed across the sentence. An example of this is provided in Example 2.12.

Example 2.12

GIRL WOMAN STRING s.t.r.i.n.g

d CUT-WITH- SCISSORS

nd CL.G string _____

“the woman cut the string”

(Leeson and Saeed, 2012: 169, Example 7.26)

The object nominal “string” is introduced before the verb and repeated or recapped by a classifier handshape during the articulation of the verb. Linear order is only part of the syntactic construction in this case.

With regard to *location verbs*, verbal arguments represent different semantic roles of source, path, goal and the moving item, which may be referred to as theme (Foley and Van Valin, 2004). Leeson and Saeed (2012) identify a typical mapping between semantic and grammatical roles would be a case where the theme role becomes the subject and the goal becomes the object. However, the order is flexible

and subject to change based on the discourse. An example to illustrate this is shown in Example 2.13, where the goal argument “SHOP” occurs first due to the signer identifying it as a topic for discourse reasons.

Example 2.13

SHOP (-sl) MAN V-CL+(c+MOVE+sl+fingers move)

“the man walked to the shop”

(Leeson and Saeed, 2012: 169, Example 7.28)

Leeson and Saeed (2012) identify that *topics* are identified by NMFs. Topics may be any argument of the verb or an adjunct eternal to the main predication. The main features identified in topic marking are a slight head tilt back and raised eyebrows during the articulation of the topic sign. Leeson (2001) also identified that these NMFs do not appear in all instances and that male signer’s are more likely to mark topics in this way. It is also possible for the topic to be followed by a slight pause.

Leeson and Saeed (2012) also identify that *passive constructions* involve a change in basic word order along with other features. Example 2.14 illustrates this, where the actor argument is omitted and the undergoer argument occurs in the initial position. The undergoer is co-referential with the signer’s c-locus. Their eyes are averted to signal lack of co-operation of the undergoer.

Example 2.14

ME BEFORE-BEFORE BEAT-Upc. (eyes averted)

“I was beaten up”

(Leeson and Saeed, 2012: 170, Example 7.30)

Vermeerbergen et al. (2007: 1) outline the complexity of simultaneity in SLs, describing how “signed language users can draw on a range of articulators when expressing linguistic messages, including the hands, torso, eye gaze, mouth, and, as many studies have shown, other facial actions”. Depending on the information being articulated, these articulators can work together to produce one lexical item or they can work to convey different types of information. This can include

simultaneously using the two hands as two separate “parallel autonomous channels”, with one hand encoding signs distinct from the other hand (Vermeerbergen et al. (ibid.).

Leeson and Saeed (2007: 70) report that simultaneity is essential to the signer’s construction of ISL discourse, identifying that the windowing of attention (Talmy, 1996: 236-237) is mediated by dominant and non-dominant hand functionality in ISL. Leeson and Saeed (2012) report that simultaneous constructions are very common in ISL with regard to location verbs and that simultaneous constructions are particularly common where a spatial relationship links two entities. One entity is defined as more prominent by factors such as animacy, viewpoint and empathy, and then this entity is represented by the dominant hand. The less-prominent entity is then represented by the non-dominant hand.

Leeson and Saeed (ibid.) identify that ISL sentences, when connected in discourse, are frequently characterised by the omission of available arguments. A common example of this would be where a nominal argument is introduced and thereafter understood over a sequence of clauses.

2.7 Summary

This chapter demonstrates that the linguistic analysis of ISL is in its infancy when compared to spoken languages. SLs are indigenous languages of their own community and country of origin and evolved naturally without reliance on spoken language. A communication barrier exists between SLs and also between SL and spoken language. We provide a motivation for the development of a linguistically motivated computational framework for ISL, which will help to alleviate the communication barrier for members of the Deaf community in Ireland. We have provided a linguistic account of the visual, gestural nature of ISL and we predict that providing a linguistically motivated computational description to underpin these complexities will be both interesting and challenging in relation to current theories of grammar and also in computational terms. It is clear at this point of investigation that the definitions of the various linguistic phenomena that occur within sign language linguistics fall between varying linguistic approaches. While our own approach lies within is a functionalist view, using RRG as a theoretical

framework within his body of work, generative descriptions that lie within the realm of the generative linguistics approach may lend themselves very well to adaptation in the development of this linguistically motivated computational framework.

3. The Theoretical Framework of this Study

3.1 Introduction

This chapter provides an account of Role and Reference Grammar (RRG), a functionalist theory of grammar, while introducing the basic components of the RRG model. We use RRG as a theory of grammar within this body of research based on its initial motivation for development and also based on the fact that the framework has previously been used successfully in the development of an Arabic-to-English machine translation system (Nolan and Salem, 2008, 2009). Bischoff and Jany (2013: 1) define functional approaches to language as being concerned the investigation of why language structure is ‘the way it is’ and also investigating explanations in language use. Butler (2003: 477) defines the functionalist approach as understanding

‘how the forms of human linguistic communication are related to the functions they serve in exchange of meanings under conditions defined by the social and cognitive contexts of use, and by the structure of the ongoing interaction itself’.

Van Valin and LaPolla (1997) describe how RRG theory was developed in an attempt to answer two simple questions: (i) What would linguistic theory look like if it was based on the analysis of other languages such as Lakota, Dyirbal and Tagalog, rather than the analysis of English, and (ii) how can the interaction of syntax, semantics and pragmatics in different grammatical systems best be captured and explained? Central to RRG are the theory is the Layered Structure of the Clause.

We pave the way for answering RQ3 and RQ4 by providing an account of the theoretical underpinnings of this framework. We argue that RRG is sufficiently flexible and robust to accommodate ISL in linguistic terms.

3.2 Background

RRG can be described as a monostratal theory positing only one level of syntactic representation, the actual form of the sentence. Therefore there is only one syntactic

representation for a sentence. This representation corresponds to the actual form of the sentence. RRG does not allow any phonologically null elements in the syntax; if there's nothing there, there's nothing there (Van Valin, 2005). Figure 3.1, from Van Valin (2005) illustrates the organisation of RRG.

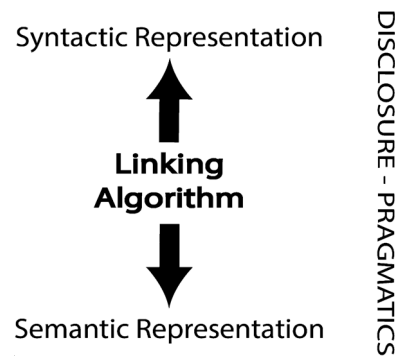


Figure 3.1 Organisation of Role and Reference Grammar, Van Valin (2005: 2)

With respect to cognitive issues RRG adopts the criterion of psychological adequacy formulated in Dik (1991), which states that a theory should be compatible with the results of psycholinguistic research on the acquisition, processing, production, interpretation and memorisation of linguistic expressions. The RRG approach to language acquisition rejects the theory that grammar is radically arbitrary and therefore unlearnable.

3.3 Syntactic Structure

Van Valin (2005) states that regarding clause structure, there are two fundamental aspects of theory that must be dealt with: relational and non-relational structure. Relational structure is concerned with relations between a predicate and its argument(s), while non-relational structure is concerned with the hierarchical organisation of phrases, clauses and sentences.

With regard to RRG, there are two general considerations that a theory of clause structure must meet: (a) It must capture all of the universal features of clauses, without imposing features on languages in which there is no evidence for them, and (b) It must represent comparable structures in different languages in comparable ways (Van Valin, *ibid.*).

3.3.1 Universal Aspects of the Layered Structure of the Clause

The layered structure of the clause applies equally to fixed word-order and free word-order languages, to head-marking and dependent-marking languages and also to languages with or without grammatical relations (Van Valin, 2005). All theories of syntax strive to develop a representation of clause structure that reflects universal distinctions made in every language (Binns-Dray, 2004). Within RRG theory, non-relational clause structure is referred to as the layered structure of the clause (LSC). The LSC is based on two fundamental contrasts: (a) Between the predicate and non-predicating elements and (b) among the non-predicating elements, between arguments and non-arguments (Van Valin, 2005).

RRG describes the primary constituent units of the clause as the ‘nucleus’, the ‘core’ and a ‘periphery’. The ‘nucleus’ consists of the predicate, which may be a verb an adjective or a nominal. The ‘core’ contains the nucleus and the arguments of the predicate. Core arguments may be direct (unmarked or marked for case) or oblique (marked by an adposition). All other elements are part of the ‘periphery’. These are usually temporal and locative modifiers of the core. The periphery subsumes non-arguments of the predicate (Van Valin, 2005). The following figures provide an informal representation of this.

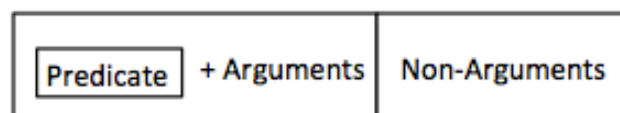


Figure 3.2 Universal Oppositions underlying clause structure, Van Valin and LaPolla (1997: 25)

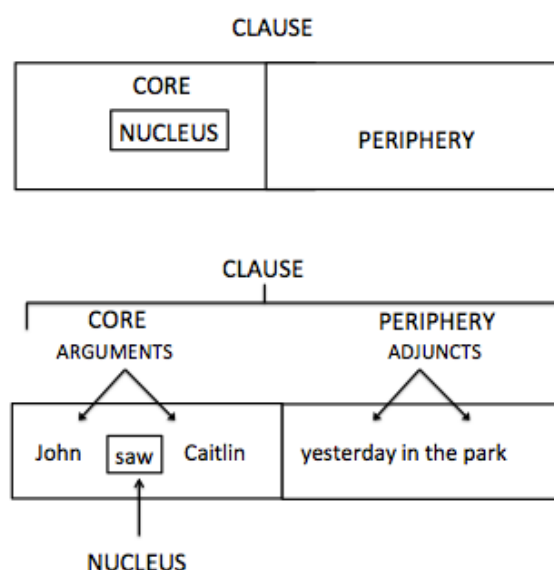


Figure 3.3 Components of the layered structure of the clause, Van Valin and LaPolla (1997: 26)

While a clause consists of a core and periphery, a sentence may contain multiple clauses (Binns-Dray, 2004). Table 3.1 from Van Valin and LaPolla (1997) shows the semantic units underlying the syntactic units represented in the LSC.

Table 3.1 The semantic units underlying the layered structure of the clause, Van Valin and LaPolla (1997: 27)

Semantic Element(s)	Syntactic Unit
Predicate	Nucleus
Argument in semantic representation of predicate	Core argument
Non-arguments	Periphery
Predicate + Arguments	Core
Predicate + Arguments + Non-Arguments	Clause = (Core + Periphery)

Being semantically and not syntactically motivated allows the elements in these units to occur in any order, provided that a given language permits it. The linear order of the elements in a clause is not affected by the layers themselves.

3.3.2 Non-Universal Aspects of the Layered Structure of the Clause

Van Valin (2005) describes how there are additional elements, which may occur in a simple sentence i.e. a single clause sentence. The first element is the ‘precore slot’ [PrCS], the position in which question words appear in languages in which they do not occur *in situ* e.g. English. The precore slot is also the position in which the fronted element in a sentence occurs, e.g. *Bean soup* I can’t stand. This can be

described in RRG as core external as opposed to clause internal. Some verb-final languages, e.g. Japanese and Dhivehi have a postcore slot' [PoCS]. Both PrCSs and PoCSs are inside the clause but outside the core.

In addition to a clause, a sentence may also include a clause in a detached position, most commonly in the 'left detached position' [LDP]. This is the location of sentence initial elements, most commonly adverbials, which are set off from the clause by a pause e.g. "Yesterday, I bought myself a new car" or "As for Jane, I haven't seen her in weeks". There is also a 'right detached position' [RDP] as in sentences like 'I know them, those children'(Van Valin, 2005). The LDP and RDP are outside the clause but inside the sentence. Figure 3.4, taken from Van Valin and LaPolla (1997) illustrates how these positions can be used to represent a sentence in English.

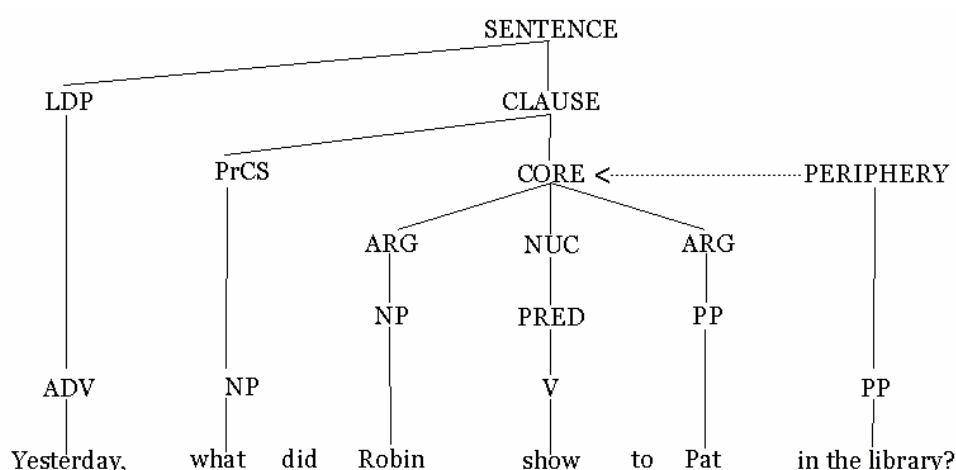


Figure 3.4 English example of constituent projection, Van Valin and LaPolla (1997: 36)

3.3.3 Operators in the Layered Structure of the Clause

Each of the major layers (nucleus, core and clause) is modified by one or more operators. Operator categories include tense, aspect, negation, illocutionary force, modality and evidentiality. Operators are another important component of the RRG theory of clause structure. An important property of operators is that they modify specific layers of the clause. Van Valin (2005) proposes the following operators in the LSC.

Table 3.2 Operators in the layered structure of the clause, Van Valin (2005: 9)

Nuclear Operators	Core Operators	Clausal Operators
Aspect	Directionals	Status
Negation	Event Quantification	Tense
Directionals	Modals	Evidentials
	Internal Negation	Illocutionary Force

Languages normally do not have all of these operators as grammatical categories; the absolutely universal ones are illocutionary force and negation. Grammatical categories like tense, aspect and modality are treated as operators, modifying different layers of the clause. Each of the clause levels may be modified by one or more different operators. *Nuclear operators* have scope over the nucleus. They modify the action, event or state itself without reference to the participant. *Core operators* modify the operation between a core argument, normally the actor and the action. *Clausal operators* modify the clause as a whole. They fall into two groups. One containing tense and status and the other evidentials and illocutionary force.

3.3.4 Formal Representation of Clause Structure

Within RRG, operators are technically not seen as part of the nucleus, core or periphery, but are modifiers of these units and combinations of them. Therefore, they are represented separately from the predicates and the arguments that they modify (Van Valin, 2005). Predicates and arguments are subject to language specific constraints on their ordering, while the principal governing the ordering of operators is the universal scope constraint.

Johnson (1987) proposed a formalisation of the layered structure of the clause to capture the differences between restrictions on predicates and arguments on one hand and operators on the other (constituent and operator projections, respectively). He called this formalisation a ‘projection grammar’. Operators are presented in a distinct projection of the clause from the predicates and arguments (the constituent projection). Recent research from Kallmeyer and Osswald (2019) describes how constituent structure and its operator projection can be integrated in a single tree based by Tree Adjoining Grammar (TAG). Figure 3.5, from Van Valin (2005), illustrates the LSC with the constituent and operator projections. Operators are represented in a separate projection of the clause, which is the mirror image of the constituent projection.

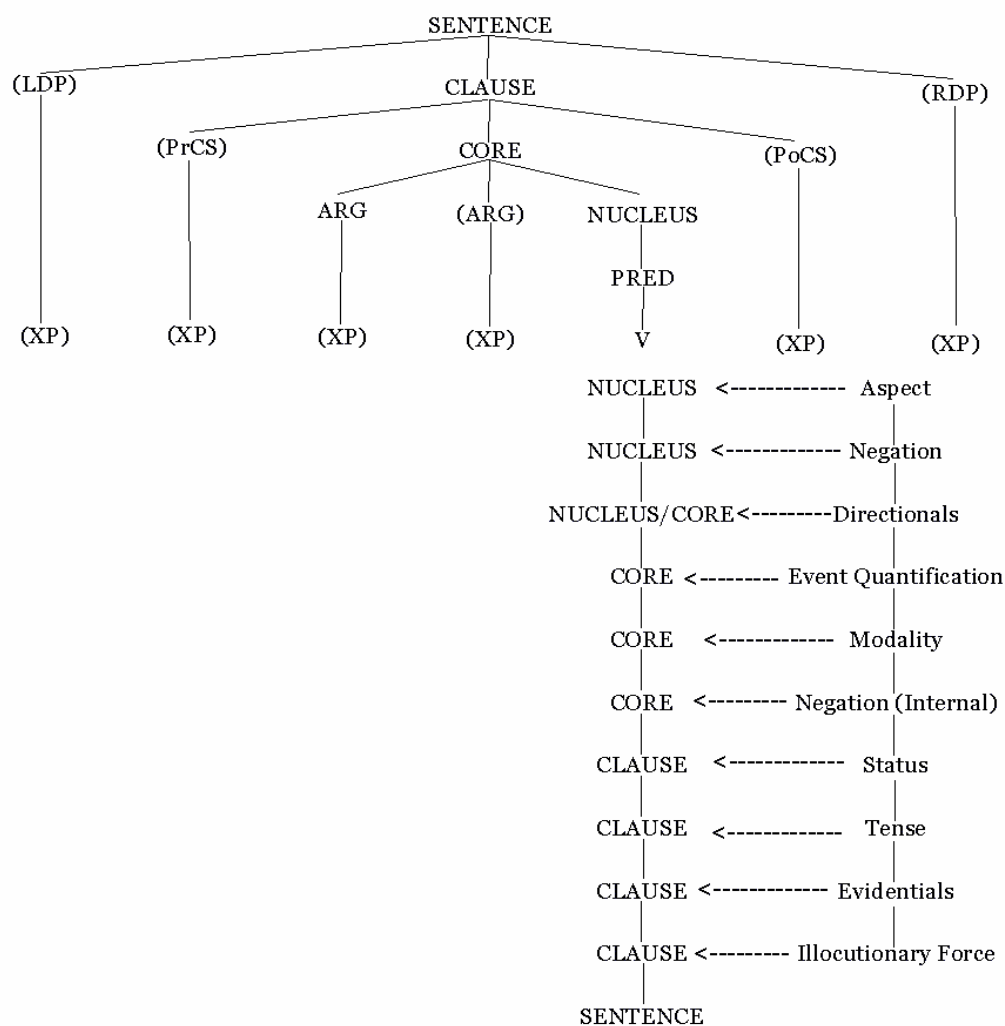


Figure 3.5 The layered structure of the clause with constituent and operator projections, Van Valin and LaPolla (1997: 49)

3.4 Verb Classes

RRG semantic representation is based on a system of lexical representation and semantic roles. RRG employs the system of lexical decomposition proposed by Vendler (1967). Saeed (2015) defines the task of a semanticist as showing “how the inherent semantic distinctions carried by verbs, and verb phrases, map into a system of situation types”. Saeed (ibid.: 119) identifies Vendler’s influential approach to doing this (Vendler, 1967: 97-121).

Within RRG, verbs are represented in the lexicon according to their Aktionsart classification. Verbs can be divided into four distinct classes: states, activities, achievements and accomplishments. These four classes can be further defined by three features: $[\pm\text{static}]$, $[\pm\text{punctual}]$, and $[\pm\text{telic}]$ (Binns-Dray, 2004). *Static*

indicates if a verb represents something happening. If one can answer the question, “What happened?” or “What is happening?” then the verb is seen to be static. *Telic* represents whether a verb describes a state of affairs that has a terminal end point. Achievements and accomplishments are telic, or bounded, as in *The clothes are drying on the line*, while states and activities are atelic, or unbounded, as in *John is running in the park*. *Punctual* represents whether a telic verb (achievements and accomplishments) has internal duration or not (Binns-Dray, 2004).

There are two additional classes; active accomplishments, which describe telic uses of activity verbs (e.g. devour) and also semelfactives (punctual events; Smith, 2009). Examples of each class and their formal representation, including their causative counterparts are provided in Example 3.1 and 3.2.

Example 3.1

- a) State: be sick, be tall, be dead, love, know, believe, have
- b) Activity: march, swim, walk (– goal PP); think, eat (+ mass noun/bare plural RP)
- c) Semelfactive: flash, tap, burst (the intransitive versions), glimpse
- d) Achievement: pop, explode, shatter (all intransitive)
- e) Accomplishment: melt, freeze, dry (the intransitive versions), learn
- f) Active accomplishment: walk (+ goal PP), eat (+ quantified RP), devour

(Van Valin and LaPolla, 1997: 105, based on Example 3.21)

Example 3.2

- a) State: The teacher is upset about the school situation.
- a' Causative state: The school situation upsets the teacher.
- b) Achievement: The bubble popped.
- b' Causative achievement: The baby popped the bubble.
- c) Semelfactive: The light flashed
- c' Causative semelfactive: The man flashed the light.
- d) Activity: The soccer ball rolled around the field.
- d' Causative activity: The girl rolled the soccer ball around the field.
- e) Active accomplishment: The soldiers marched to the barracks.
- e' Causative active accomplishment: The sergeant marched the soldiers to the barracks.
- f) Accomplishment: The snow melted.
- f' Causative accomplishment: The hot sun melted the snow.

(Van Valin, 2005b: 10, based on Example 5)

3.4.1 Lexical representation of verb classes

A single verb can have more than one *Aktionsart* interpretation. For example the verb ‘*march*’ would be listed in the lexicon as an activity verb, and lexical rules would derive the other uses from the basic activity use. The lexical representation of a verb or other predicate is termed its LOGICAL STRUCTURE [LS]. State predicates are represented simply as **predicate'**, while all activity predicates contain **do'**. Accomplishments, which are durative, are distinguished from achievements, which are punctual. Accomplishment LSs contain BECOME, while achievement LSs contain INGR, which is short for ‘ingressive’. Semelfactives contain SEML. In addition, causation is treated as an independent parameter that crosscuts the six *Aktionsart* classes. It is represented by CAUSE in LSs. The lexical representations for each type of verb shown above are given in Table 3.3.

Table 3.3 Lexical representation for Aktionsart classes, Van Valin and LaPolla (1997: 109)

Verb Class	Logical Structure
State	predicate' (x) or (x, y)
Activity	do' (x, [predicate' (x) or (x, y)])
Achievement	INGR predicate' (x) or (x, y), or INGR do' (x, [predicate' (x) or (x, y)])
Accomplishment	BECOME predicate' (x) or (x, y), or BECOME do' (x, [predicate' (x) or (x, y)])
Active accomplishment	do' (x, [predicate ₁ ' (x, (y))]) & BECOME predicate ₂ ; (z, x) or (y)
Causative	α CAUSE β where α, β are representations of any type

Examples of simple English sentences with the LS of the predicate are presented below, some provided by Van Valin and LaPolla (1997).

Example 3.3

STATES:

Peter is a clown
be' (Peter, [**clown'**])

Sean saw the photo
see' (sean, photo)

The mirror is shattered
shattered' (mirror)

Joe is at the club
be-at' (club, Joe)

(Van Valin and LaPolla, 1997: 105, based on Example 3.21)

Example 3.4

ACTIVITIES:

The baby cried
do' (baby, [**cry'** (baby)])

James ate pizza
do' (James, [**eat'** (James, pizza)])

(Van Valin and LaPolla, 1997: 105, based on Example 3.21)

Example 3.5

SEMELFACTIVES:

The light flashed
SEML **do'** (light, [**flash'** (light)])

John glimpsed Mary
SEML **see'** (John, Mary)

(Van Valin and LaPolla, 1997: 105, based on Example 3.21)

Example 3.6

ACHIEVEMENTS:

The window shattered
INGR **shattered'** (window)

The balloon popped.
INGR **popped'** (balloon)

John glimpsed the picture
INGR **see'** (John, picture)

(Van Valin and LaPolla, 1997: 105, based on Example 3.21)

Example 3.7

ACCOMPLISHMENTS:

The snow melted.
BECOME **melted'** (snow)

The sky reddened.
BECOME **red'** (sky)

Niamh learned Spanish.
BECOME **know'** (Niamh, Spanish)

(Van Valin and LaPolla, 1997: 105, based on Example 3.21)

Example 3.8

ACTIVE ACCOMPLISHMENTS:

James ate the pizza.
do' (James, [**eat'** (James, pizza)]) & BECOME **eaten'** (pizza)

John ran to the shelter.
do' (John, [**run'** (John)]) & BECOME **be-at'** (shelter, John)

(Van Valin and LaPolla, 1997: 111, based on Example 3.30)

Example 3.9

CAUSATIVES:

The monster scared the boy.
[**do'** (monster, Ø)] CAUSE [**feel'** (boy, [**afraid'**])]

Brian broke the window.
[**do'** (Brian, Ø)] CAUSE [BECOME **broken'** (window)]

The cat popped the balloon.
[**do'** (cat, Ø)] CAUSE [INGR **popped'** (balloon)]

The girl walked the dog to the park.
[**do'** (girl, Ø)] CAUSE [**do'** (dog, [**walk'** (dog)]) & BECOME **be-at'** (park, dog)]

(Van Valin and LaPolla, 1997: 105, based on Example 3.23)

3.4.2 Semantic Roles

RRG employs two types of semantic roles, specific and general. The specific semantic roles correspond closely to thematic relations posited in other theories. The logical structure of a verb reveals its relevant semantic properties, and these properties identify the thematic relations (Binns-Dray, 2004). Thematic relations describe the relation between a predicate and its arguments, which express the participant roles in the state of affairs denoted by the verb (Van Valin and LaPolla, 1997). Thematic roles include familiar notions such as *agent*, *theme*, *patient*, and *experiencer*. Following Jackendoff (1976), Van Valin and LaPolla adopted a system wherein only states and activities define thematic relations. All other types are derived from these two basic verb class types (Van Valin and LaPolla 1997).

The second type of semantic role, which is generalised semantic role or semantic macrorole, plays a crucial role in the linking system. There are two semantic macroroles defined by RRG. These are ACTOR and UNDERGOER, and they are the two primary arguments of a transitive predication. By default, the most agent-like argument is the actor, and the most patient-like argument is the undergoer. The basic distinction is illustrated in the following German examples in 3.10.

Example 3.10

- a) Der Junge [SUBJ, ACTOR] hat den Kuchen [OBJ, UNDERGOER] aufgegessen.
'The boy ate the cake.'
- b) Der Hund [SUBJ, ACTOR] ist um das Haus herumgelaufen.
'The dog [SUBJ, ACTOR] ran around the house.'
- c) Der Hund [SUBJ, UNDERGOER] ist gestorben.
'The dog [SUBJ, UNDERGOER] died.'
- d) Der Kuchen [SUBJ, UNDERGOER] wurde vom Jungen [ACTOR] aufgegessen.
'The cake [SUBJ, UNDERGOER] was eaten by the boy [ACTOR].'

(Van Valin, 2005b: 16)

Actor and undergoer are generalisations across specific semantic argument types, as defined by Logical Structure (LS) positions. This is illustrated in 3.11 below.

Example 3.11

- a) *kill* [**do'** (x, Ø)] CAUSE [BECOME **dead'** (y)]
 - b) *see* [**see'** (x, y)]
 - c) *put* [**do'** (x, Ø)] CAUSE [INGR **be-LOC'** (y, z)]
 - d) *present* [**do'** (x, Ø)] CAUSE [INGR **have'** (y, z)]
- 
 Actor


 Undergoer

(Van Valin and LaPolla, 1997: 155, Example 4.16)

The *x* argument of all of these verbs functions as the actor, regardless of whether it is the first argument of the generalized activity verb **do'** (conventionally labeled 'effector'), as with *kill*, *put* and *present*, or the first argument of a two-place state predicate, as with *see*. With two-place transitive verbs like *kill* and *see*, the *y* argument is the undergoer. With three-place verbs like *put* and *present* (as in *Bill presented Mary with the flowers*), on the other hand, the situation is more complex. The relationship between LS argument positions and macroroles is captured in the Actor-Undergoer Hierarchy, henceforth termed AUH, in Figure 3.6. The basic idea of the AUH is that in a LS the leftmost argument in terms of the hierarchy will be the actor and the rightmost will be the undergoer. This was true for *kill*, *see* and *put* in Example 3.11. It was not true for *present*, however, and this illustrates how the leftmost argument in a LS (in terms of the AUH) is always the actor, but the rightmost argument is only the default choice for undergoer.

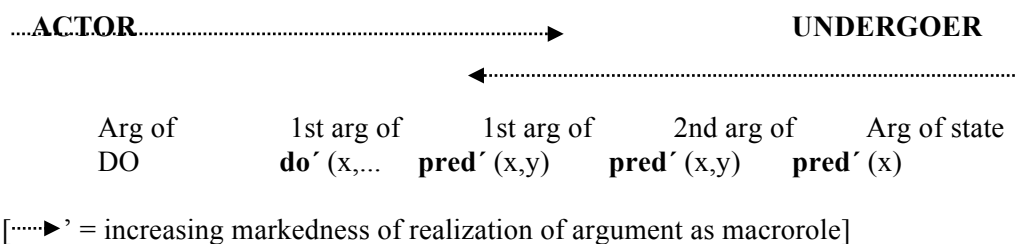


Figure 3.6 The RRG actor-undergoer hierarchy, Van Valin and LaPolla (1997: 146)

Transitivity in RRG is defined semantically in terms of the number of macroroles a predicate takes. This is termed ‘M-transitivity’ in RRG. The number of syntactic arguments a predicate takes is described as its ‘S-transitivity’. The three M-transitivity possibilities are: transitive (2 macroroles), intransitive (1 macrorole), and atransitive (0 macroroles). The theoretical label for the third argument in a ditransitive predication, e.g. *the picture* in the English sentence *Sam showed Sally the picture*, is ‘non-macrorole direct core argument’ (Van Valin, 2005). The principles determining the M-transitivity of verbs are provided as the default macrorole assignment principles in the examples below, which are taken from Van Valin (2005).

Example 3.12

- a) Number: The number of macroroles a verb takes is less than or equal to the number of arguments in its LS.
 1. If a verb has two or more arguments in its LS, it will take two macroroles. RRG treats the notion of ‘agent’ rather differently from other theories. The basic notion is ‘effector’, which is the first argument of **do**’ and is unspecified for agentivity. With many verbs, a human effector may be interpreted as an agent in certain contexts. If the verb lexicalizes agentivity, as with *murder*, then the logical structure contains ‘DO’, which indicates that the argument must be interpreted as an agent. Also, primary-object language patterns require a modified undergoer selection principle, namely that the undergoer is the second-highest ranking argument in the LS.
 2. If a verb has one argument in its LS, it will take one macrorole.
- b) Nature: For predicates which have one macrorole:
 1. If the verb LS contains an activity predicate, the macrorole is actor.
 2. If the predicate has no activity predicate in its LS, it is undergoer. If a verb is irregular and has exceptional transitivity, it will be indicated in its lexical entry by ‘[MR α]’, where ‘ α ’ is a variable for the number of macroroles.

(Van Valin, 2005a: 63, based on Example 2.41)

Examples of partial lexical entries for some English verbs are provided in Example 3.13.

Example 3.13

- a) *kill*
[**do'** (x, Ø)] CAUSE [BECOME **dead'** (y)]
- b) *receive*
BECOME **have'** (x, y)
- c) *own*
have' (x, y)
- d) *belong (to)*
have' (x, y) [MR1]
- e) *see*
see' (x, y)
- f) *watch*
do' (x, [**see'** (x, y)])
- g) *show*
[**do'** (w, Ø)] CAUSE [BECOME **see'** (x, y)]
- h) *run*
do' (x, [**run'** (x)])
- i) *drink*
do' (x, [**drink'** (x, y)])

(Van Valin, 2005: 66, based on Example 2.42)

Within the theory of RRG no syntactic sub categorisation information of any kind is required in the lexical entries for verbs. All of the major morphosyntactic properties of verbs and other predicates follow from their LS together with the linking system (Van Valin, 2005).

3.5 Grammatical relations

Grammatical relations like subject and direct object are considered to be non-universal in RRG. In place of these notions, RRG employs the notion of 'privileged syntactic argument' [PSA], which is a construction-specific relation and is defined as a restricted neutralisation of semantic roles and pragmatic functions for syntactic purposes (Van Valin, 2005). The other arguments in a clause are characterised as direct or oblique core arguments; there is nothing in RRG corresponding to direct or indirect object (Van Valin 2005, chapter 4). Languages have selection hierarchies to determine the PSA. The privileged syntactic argument selection hierarchy is shown in Figure 3.7.

Arg of DO > 1st arg of **do'** > 1st arg of **pred'** (x,y) > 2nd arg of **pred'** (x,y) > **pred'** (x)

Figure 3.7 Privileged syntactic argument selection hierarchy, Van Valin and LaPolla (1997: 175)

In syntactically accusative languages like English and Croatian, the highest ranking macrorole is the default choice for PSA, whereas in syntactically ergative languages like Dyirbal and Sama, the lowest ranking macrorole is the default choice (Van Valin, 2005). In a syntactically ergative language, the unmarked choice for the PSA of a transitive verb is the undergoer, with the actor being a marked choice possible only in an anti-passive construction. With an intransitive verb, the hierarchy is irrelevant, as the single macrorole functions as PSA regardless of whether it is actor or undergoer. The linking system relating semantic and syntactic representations is illustrated in Figure 3.8. Syntactic functions like PSA and direct core argument (which are structurally instantiated in the LSC) represent the syntactic pole of the system, while LSs represent the semantic pole.

3.6 The Linking System

The linking system in RRG is described as bi-directional, in that it maps from syntax to semantics and from semantics to syntax. The linking between semantics and syntax has two phases. The first phase consists of the determination of semantic macroroles based on the logical structure of the verb (or other predicate) in the clause. This initial phase leads to the construction of the semantic representation of the clause, which occurs in the lexicon and starts from the logical structure of the main verb or predicate (Mairal Uson et al., 2006). The second phase is concerned with the mapping of the macroroles and other arguments into the syntactic functions (Van Valin, 2005). Figure 3.8 provides a summary of the RRG linking system and following on from this Example 3.14 and 3.15 provides a step-by-step analysis of a simple intransitive sentence and the resulting logical structure, using RRG. This is based on Van Valin (2005: 35-63). Figure 3.9 provides the resulting tree structure to Example 3.14 and 3.15 with constituent and operator projections.

SYNTACTIC FUNCTIONS: PSA Direct Core Arguments Oblique Core Arguments

Privileged Syntactic Argument [PSA] Selection:

Highest ranking MR = default (e.g. English)

Lowest ranking MR = default (e.g. Dyirbal)

SEMANTIC MACROROLES

Actor

Undergoer

ACTOR

UNDERGOER

Arg of 1st arg of 1st arg of 2nd arg of Arg of state
DO **do'** (x... **pred'** (x,y) **pred'** (x,y) **pred'** (x)
 [' = increasing markedness of realization of argument as macrorole]

Transitivity = No. of Macroroles [MR α]

Transitive = 2

Intransitive = 1

Atransitive = 0

Argument Positions in **LOGICAL STRUCTURE**

Verb Class

Logical Structure

STATE **predicate'** (x) or (x,y)

ACTIVITY **do'** (x, [**predicate'** (x) or (x, y)])

ACHIEVEMENT INGR **predicate'** (x) or (x,y)

ACCOMPLISHMENT BECOME: **Predicate'** (x) or (x,y)

ACTIVE ACCOMPLISHMENT

do' (x, [**predicate** 1' (x, (y»)] & BECOME **predicate** 2' (z, x) or (y)

CAUSATIVE α CAUSE β , Where α , β are LSs of any type

Figure 3.8 Summary of the RRG linking system, Van Valin and LaPolla (1997: 177)

Example 3.14

'The book is sitting on the table'

Step 1: Construct semantic representation in Lexicon.

a) Access LS for *sitting* and select prepositional LS to fill **be-LOC'** slot in LS, *on*:

do' (x [**sit'** (x, [**be-LOC'** (y, x))] + **be-on'** (__, __)]) =>

do' (x [**sit'** (x, [**be-on'** (y, x)])])

b) Determine the value of the operators to be expressed:

<IF DEC <TNS PRES < **do'** (x, [**sit'** (x, [**be-on'** (y, x)])])>>>

- c) Select the referring expressions to fill the variable positions in LS:
 <IF DEC <TNS PRES < **do'** (Book, [**sit'** (Book, ([**be-on'** (Table, Book)))]>>>>

Step 2: Determine actor and undergoer assignments:

<IF DEC <TNS PRES < **do'** (ACT: Book, [**sit'** (Book, [**be-on'** (Table, Book)))]>>>>

Step 3: Determine the morphosyntactic coding of the arguments

- a) PSA selection: Actor as sole macrorole is selected as PSA.
- b) Actor is assigned nominative case as highest ranking macrorole; preposition *on* is assigned to *the table*, which receives dative case due to being the first argument of **be-on'**, a static location.
- c) As the tense is present, the agreement marking is on the nucleus. The nucleus will agree with the actor since it is the highest ranking macrorole.

Step 4: Select syntactic templates:

- a) Select the PrCS template, which is obligatory in main declarative clauses.
- b) d. n. a.
- c) Select a two-place core, one place for the nucleus and one for the PP.
- d) Select the non-branching nucleus template.
- e) Select two common noun NP templates and a predicative PP template.

Step 5: Assign LS elements to positions in the syntactic representation:

- a) Assign the predicate to the nucleus.
- b) Join the operator projection template to the nucleus and attach the morphemes expressing operators to it.
- c) (1.a). Since the nucleus is finite, link it to the first position in the core.
- d) Link the nominative case-actor *The Book* to the PrCS.
- e) Link the PP to the remaining core position.

(Van Valin, 2005: 35-63)

Example 3.15 worked example of 3.14

Verb: *sit* $\text{do}'(x, [\text{sit}'(x, ([\text{be-LOC}'(y, x)]))])$

Operators:

$\langle \text{IF} \langle \text{TNS} \langle \text{STA} \langle \text{NEG} \langle \text{MOD} \langle \text{DIR} \langle \text{ASP} \langle \text{LS} \rangle \rangle \rangle \rangle \rangle \rangle \rangle \rangle$

Nuclear auxiliaries: (attach to the nucleus when they are non-finite; they do not attach to the nucleus when they are finite): ['be'] locative predication

Preposition: *on* $\text{be-on}'(x, y)$

Nouns:

Book n

Table n

Articles: Definite: *the*

$\text{do}'(\text{Book}, [\text{sit}'(\text{Book}, [\text{be-on}'(\text{Table}, \text{LEXICON Book}))])$

(Van Valin, 2005: 35-63)

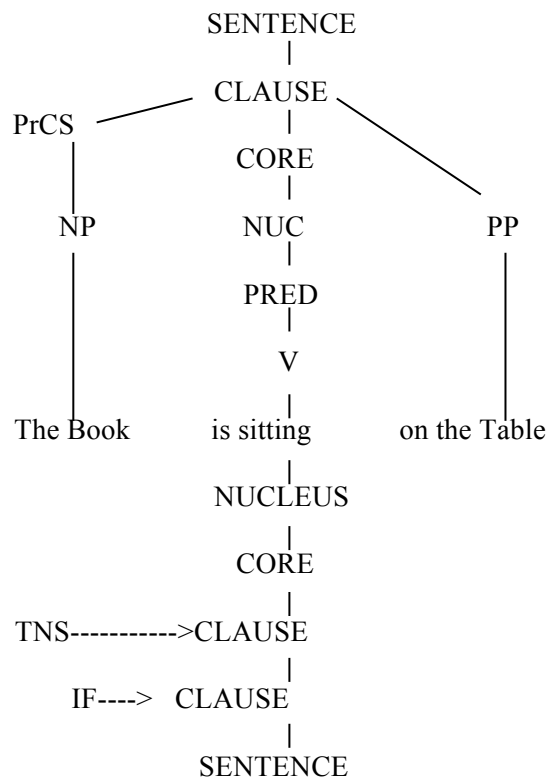


Figure 3.9 Resulting tree structure with constituent and operator projections, Van Valin (2005: 35-63)

3.7 Summary

In this chapter we provided an account of RRG, a theory of grammar concerned with the interaction of syntax, semantics and pragmatics in grammatical systems. Central to this theory is the layered structure of the clause and in this chapter we provided an account of this in terms of spoken English. We provide an account of the bi-directional nature of the linking system mapping from syntax to semantics and semantics to syntax. We provide tree structures projections to reflect the Layered Structure of the Clause and in doing so we pave the way for our discussion within this body of work on elements of the RRG framework that may be leveraged and extended to encapsulate the linguistic phenomena pertinent to ISL. In doing so we motivate further investigation into the development of the lexicon morphological/phonological interface for ISL.

4. The Lexicon Morphological-Phonological Interface in ISL

4.1 Introduction

This chapter addresses RQ2 and identifies how we motivate the phonological-morphological interface in ISL. Prior to preparing a linguistically motivated computational definition of lexicon entries that are sufficient to represent ISL we must first define ISL phonological parameters in computational terms. 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 use a humanoid model within three-dimensional (3D) space. In order to define a linguistically motivated computational model we must be able to refer to the various articulators (hands, fingers, eyes, eyebrows etc.), as these are what we use to articulate various phonemes, morphemes and lexemes of an utterance (Murtagh 2011a, 2011b). On completion of our avatar, we will 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 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. In this chapter a point in space refers to a geometric point in 3D space and therefore x, y and z co-ordinates will represent locations along the x, y and z-axis respectively.

We describe the steps involved in the development of our humanoid avatar and proceed to define a number of computational phonological parameters, which will be utilised in our framework to represent both MF and NMF.

4.2 Building an ISL Avatar

To date, research in the area of human modelling and animation for Sign Language has reached the point where it is possible to construct a human avatar that is articulate and responsive enough to perform Sign Language. It is possible for Sign Language users to view onscreen animations and successfully interpret the movements of an avatar to understand its meaning. However, to date, there is no standard computational linguistic framework available to link the divide between

the linguistic and the animation interface. Kipp et al. (2011: 115) report that signing avatars are a relatively young research area with two decades of active research and some significant results. With regard to signing avatar research there are two general approaches taken: concatenative and articulatory. While the concatenative approach applies concatenation to chunks of ‘human motion’, articulatory approaches compute ‘motion-on-the-fly’ based on some type of specification (Kipp et al., *ibid.*)

It is reasonable to assume that due to the visual gestural nature of ISL, the output from our linguistically motivated computational framework will be realised in the form of ISL synthesis. This can be achieved in computational terms by manipulating a computational model of a humanoid avatar within 3D space. It is important to note at this point that the motivation for the development of an avatar within this body of work is not as a proof of concept but as a method to inform the design of our linguistically motivated computational framework as well as other related theoretical extensions.

In order to provide some insight into computational modelling and 3D space and therefore clarify associated terminology that will be used in relation to this in the development of our framework, an overview of the development process in 3D space will be provided in this section, along with an introduction to 3D animation technological terminology.

4.2.1 Avatar Technologies

This section refers to the development of an avatar using a software tool called MakeHuman and a 3D graphics and animation application called Blender. The terminology for the development process in the development of a 3D avatar model is similar irrespective of the technologies used. The following is an overview of avatar development process.

MakeHuman [MakeHuman] and Blender [Blender] are the core technologies used in this avatar development. MakeHuman is an open source, innovative and professional software tool that can be utilised for the development of 3-Dimensional humanoid characters. MakeHuman provides for the creation of virtual humanoid characters through the manipulation of a base polygonal mesh. It is possible to

sculpt and shape the mesh provided by MakeHuman, by manipulating various user interface parameters. The mesh can then be exported in various formats for further use and development.

Blender is an open source, cross platform 3D graphics and animation application that provides capabilities for the development of images and animations through 3D modelling and rendering. Blender was chosen as a tool for this research as it provides extensive capabilities that will aid in the development of an embodied conversational agent. Blender provides its own avatar rendering engine, which provides capabilities for real time processing. Some of the more important features that Blender provides for this research include: 3D modelling, rigging, skinning, animation, non-linear animation, shape keys, simulation and rendering, UV mapping, texturing. It provides a powerful character animation toolkit, advanced simulation tools including cloth and softbody dynamics and most importantly it supports the use of Python for embedded scripting. This provides Python scripting access for custom and procedural animation effects. Another important feature of Blender is its cross platform capabilities, enabling it to run on multiple computer platforms including Microsoft Windows, Mac OS X and Linux. The initial version of Blender used for this development was version 2.49b. We are currently using version 2.79.

4.2.2 Building an Avatar Rig

Within the Blender environment, the initial stage of avatar development in character animation involves working with a skeleton referred to as an *armature*. An armature behaves in a similar fashion to the human skeleton. The bones of the armature can be connected by using an array of different approaches, resulting in a controllable, intuitively movable character rig. We have added constraints to our rig so that its movement is similar to that of the human skeleton. We have applied a driver controller to each finger, which allows us to apply inverse kinematics (IK) to the child nodes attached to this. This means that if we move the fingers by manipulating the driver, the rest of the fingers will follow and move similar to a human skeleton. We show as an example the right hand armature, which includes added constraints, which are the visible dashed lines in Figure 4.1. The process of building an armature is called rigging. Figure 4.1 below also provides a front view of the

armature taken from Blender 2.49b. The armature gives the avatar structure while also providing a mechanism for creating and holding poses. Figure 4.2 and also Figure 4.3 provide an overview of the avatar joint hierarchy as it was developed in Blender for ISL MFs and NMFs respectively.

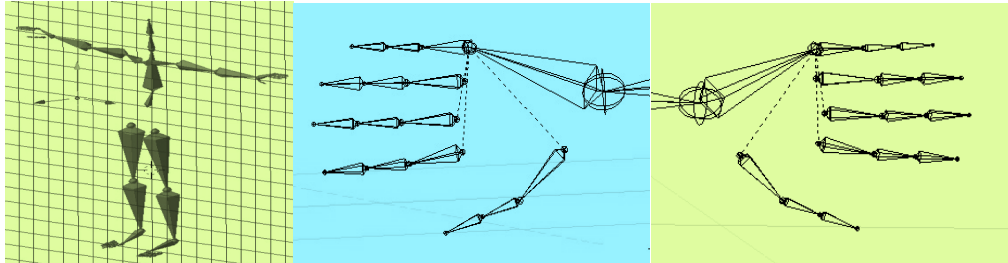


Figure 4.1 The Blender rig and armature of the right hand and left hand respectively

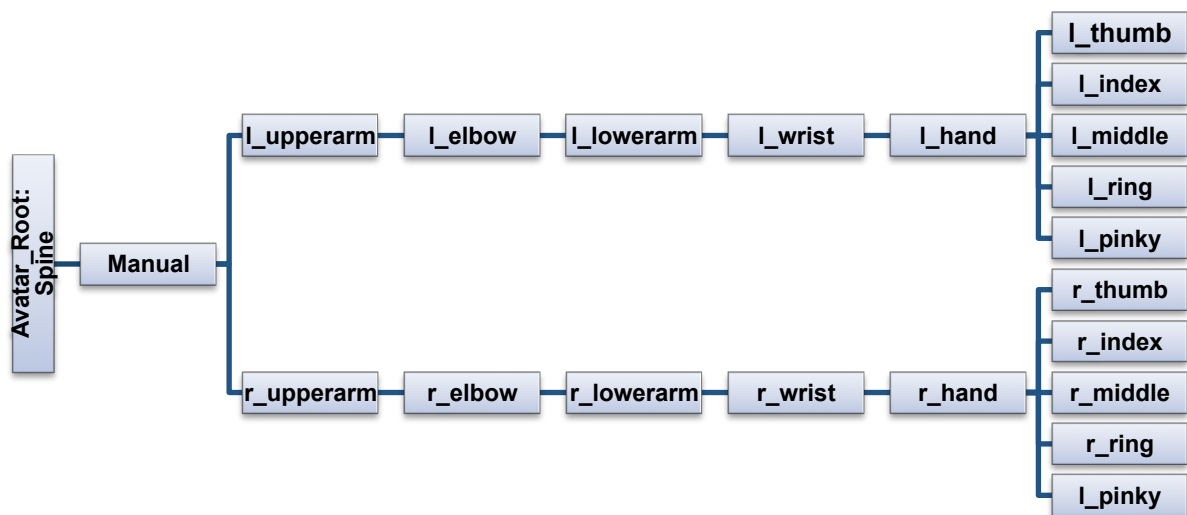


Figure 4.2 The avatar joint hierarchy for ISL MFs

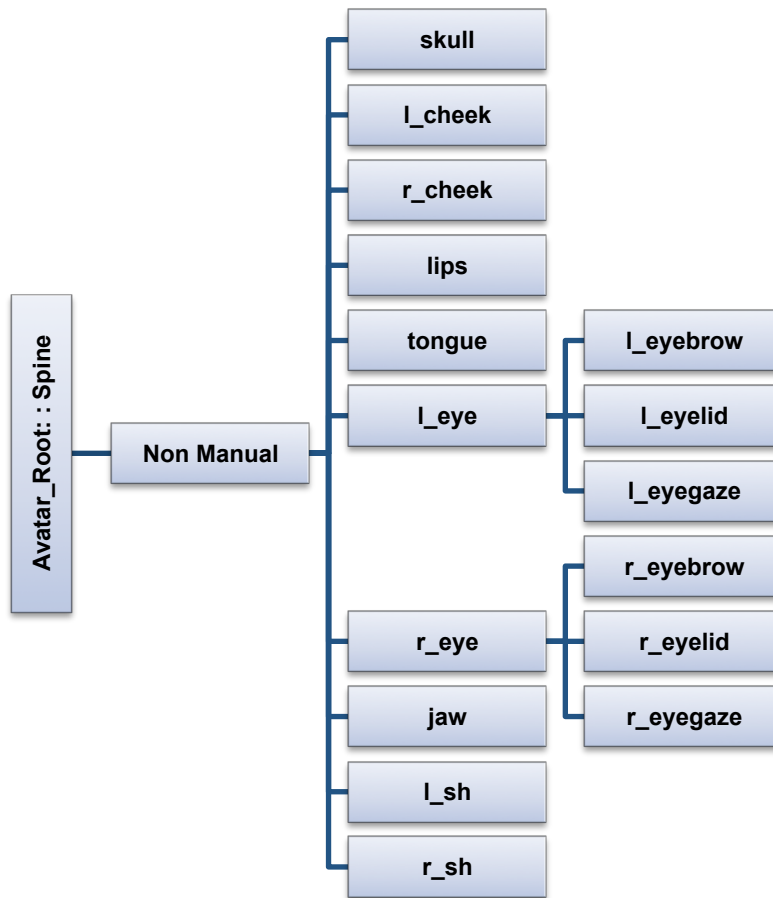


Figure 4.3 The avatar joint hierarchy for ISL NMFs

4.2.3 Skinning: Attaching the Armature to the Mesh

Before it is possible to animate the armature it must be attached to the mesh object. The process of attaching an armature to a mesh is called *skinning*. The mesh used in this research was imported from MakeHuman and then our custom built armature was added to the mesh. Figure 4.4 provides images of the right hand while in Blender ‘edit’ mode. We also provide an image with the base polygonal mesh visible.



Figure 4.4 Various orientations and views of the right hand in Blender

4.2.4 Completing the Avatar

Figure 4.5 provides a front image view of our completed avatar in Blender. The Blender particle system was used to add hair and eyebrows to the mesh. Vertex groups for the scalp and the eyebrows were created. Blender's particle system was used to allocate hair particles to the designated groups. The clothing and footwear were developed by using a 'plane' mesh. This mesh was edited and sculpted into clothing and footwear using many of the tools and modifiers supplied by Blender.

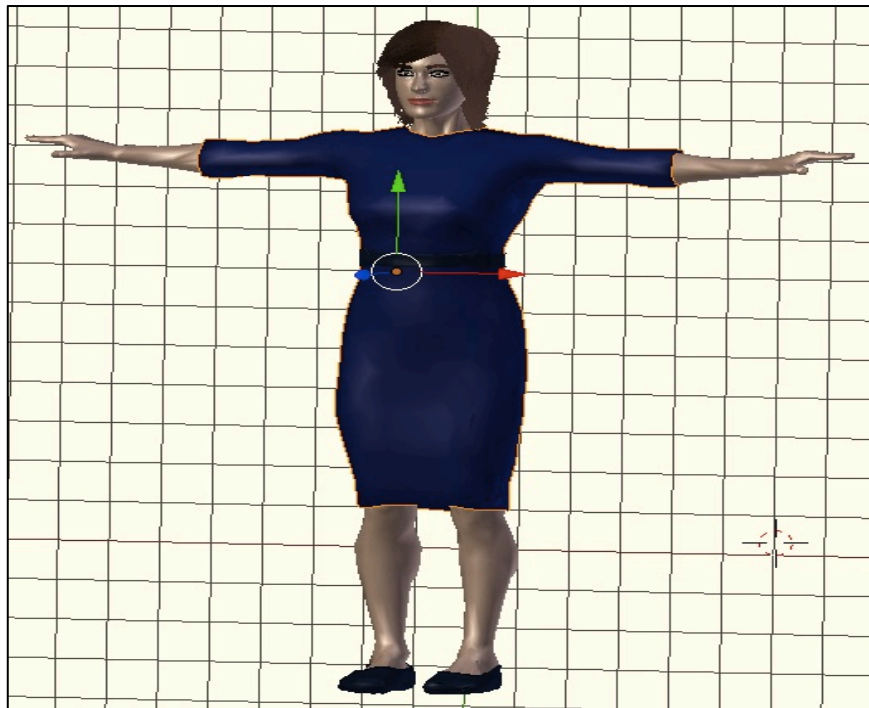


Figure 4.5 The completed avatar in Blender

4.3 ISL Computational Phonological Parameters

As discussed in chapter 2, the existence of manual 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).

The visual gestural realisation of a word in SL involves the simultaneous and parallel expression of a varied number of manual and NMFs. MF phonological parameters can be defined as *location, orientation, movement* and *handshape* or *relative configuration*. 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 include *head tilting* and *shoulder movement*.

In terms of the development of a linguistically motivated computational framework for ISL a list of ISL phonological parameters for both MF and NMF must be rigorously described and defined in computational terms. In order to adequately represent a grammatically coherent and credible SL utterance in computational terms, we must not only describe the computational phonological parameters that are used to represent the content of an utterance, but we must also consider the behaviour of these in relation to temporal information. Any given ISL phoneme, morpheme or lexeme may be realised simultaneously and in parallel along a timeline. The order or linear sequence in which these units are realised along a timeline is significant with regard to the syntax and semantics of SL. Due to the visual spatial nature of ISL various information pertinent to signed lexical items must be accounted for to accurately represent the language. 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. Parameters relating to this temporal information must be considered at this point. Another parameter that must also be considered is the signing space parameter. O'Baoill and Matthews (2000), describe the signing space as the space within which all signs must be articulated. The position of the hands in 3D space has consequences at a syntactic and also at a semantic level for ISL. Also,

morphemes are articulated at particular points or loci in relation to the signer for pronominal and anaphoric reference.

4.4 Computational Phonological Parameters for ISL Manual Features

The MF components of ISL include handshape or relative configuration, location, orientation and movement. These will be discussed further in the sections following.

4.4.1 Handshape

In chapter 2 we presented the 66 base handshapes of ISL identified by O’Baioill and Matthews (2000), further expanded to a total of 79 handshapes by Matthews (2005). These handshapes are used within ISL in the formation of signed vocabulary. O’Baioill and Matthews (2000) describe how signs are formed by applying a set of phonological rules to a combination of handshapes. Identification of these handshapes and permissible combinations provides us with an understanding of the building blocks of the formation of signs. With regard to our computational framework we now define the various articulators used in the formation of the various handshapes. We define these articulators in relation to the right hand, however the theory applies to both the left and the right hand of the signer.

The handshape parameter refers to the position of the fingers and thumb of the hand in 3D space. This must include four separate x, y, z co-ordinates, each representing an Inverse Kinematics (IK) driver for the four fingers ²(f1, f2, f3, f4) and also parameters referring to the thumb and position of the thumb. The IK driver is a node sitting above each finger, which allows us to drag the chain of bones within each finger similar to human skeletal finger movement. Within 3D space the thumb can rotate 360 degrees around a central axis. It may also be overlapped across a fist or sit at a point along a line in relation to the palm of the hand. It is assumed that the thumb has been developed and constrained within 3D space to reflect similar capabilities and constraints to a normal human hand thumb.

² f1, f2, f3 and f4 refer to the index, middle, ring and pinky (little finger) respectively. Please refer to Figure 4.1 to visualize these.

movement. The handshape computational parameters used to represent the thumb are: $\text{thumb}(x, y, z)$, $\text{tOverlap}(x, y, z)$ and $\text{tPalm}(x, y, z)$.

An initial default resting handshape will be defined to represent the default resting handshape in 3D space. Figure 4.6 illustrates the layout of the hand armature within 3D space, with the circular nodes on the tip of each finger and the thumb illustrating the IK driver, which is represented as a point (x, y, z) in 3D space. Table 4.1 provides an overview of the articulators and our proposed computational within 3D space.

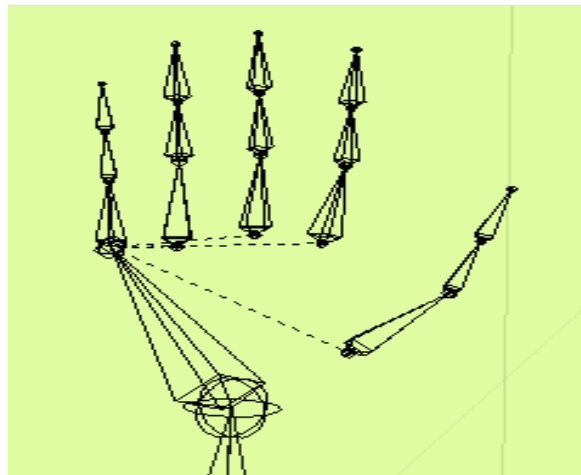


Figure 4.6 The armature hand in 3D space with IK driver nodes on the tips of fingers and thumb

Table 4.1 ISL handshape computational parameters

Articulator	Computational Parameter
pinky (little finger)	$f4\text{Shape}(x,y,z)$
ring finger	$f3\text{Shape}(x,y,z)$
middle finger	$f2\text{Shape}(x,y,z)$
index finger	$f4\text{Shape}(x,y,z)$
thumb	$\text{thumb}(x, y, z)$ $\text{tOverlap}(x, y, z)$ $\text{tPalm}(x, y, z)$

4.4.2 Hand Movement

This parameter refers to the hand movement or rotation of the hand in relation to the wrist. When the wrist rotates from the default resting position the hand can pivot on

the wrist joint upwards to an angle of approximately 80 degrees and it can also pivot from the default resting position downwards to an angle of approximately 80 degrees. The wrist can also pivot from the default resting position to the left and to the right to approximately 20 degrees respectively. Parameters for the movement of the hand are further illustrated in Figure 4.7, where $wDef(x,y,z)$ represents our default resting position for the wrist and $w1(x,y,z)$, $w2(x,y,z)$, $w3(x,y,z)$, $w4(x,y,z)$ represent values for possible wrist movements along four different paths, upwards, downwards, to the right and to the left respectively.

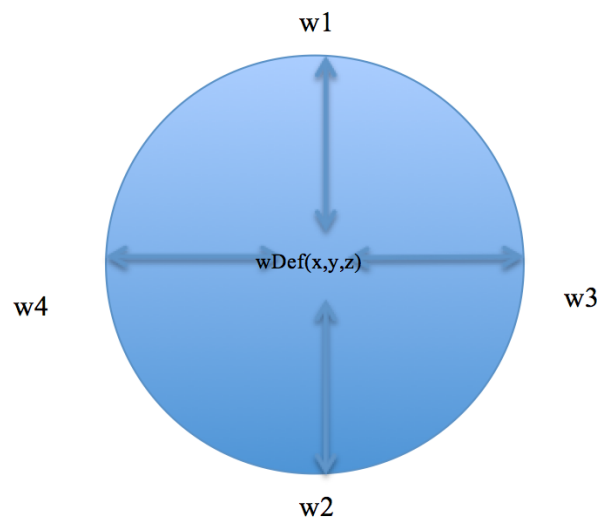


Figure 4.7 Wrist movement parameters in relation to the movement of the wrist joint

4.4.3 Forearm

The forearm parameter refers to the movement of the forearm in relation to the elbow joint. We refer to the initial position of our forearm as our initial point $fDef(x,y,z)$, which will be set to a default resting position parameter for both the left and right forearm. This will initially be set to a value that represents the forearm in its default resting position. This parameter will be over-written as the computational phonological parameters within an utterance are realised, in which case any new value from point $f1$ to $f8$ illustrated in Figure 4.8 will then become the initial parameter and new values for $f1$ to $f8$ will be set as necessary as an utterance is realised.

We propose that in relation to the elbow, the forearm, which includes the wrist, hand and fingers as children nodes and are therefore bound to the forearm, can

move in 8 possible directions or paths within our signing space in order to articulate a manual sign. These eight forearm movement parameters can be mapped to the 8 parameters outlined in Figure 4.8, where the initial point is the default position of our the forearm and the points f1 to f8 define a line of movement in 3D space starting with the forearm in an initial position $i(x,y,z)$ and then moving in the direction of our chosen parameter f1 to f8. The forearm movement can stop at any point along a line for parameters f1 to f8. Forearm movement is constrained according to human skeletal and muscular constraints.

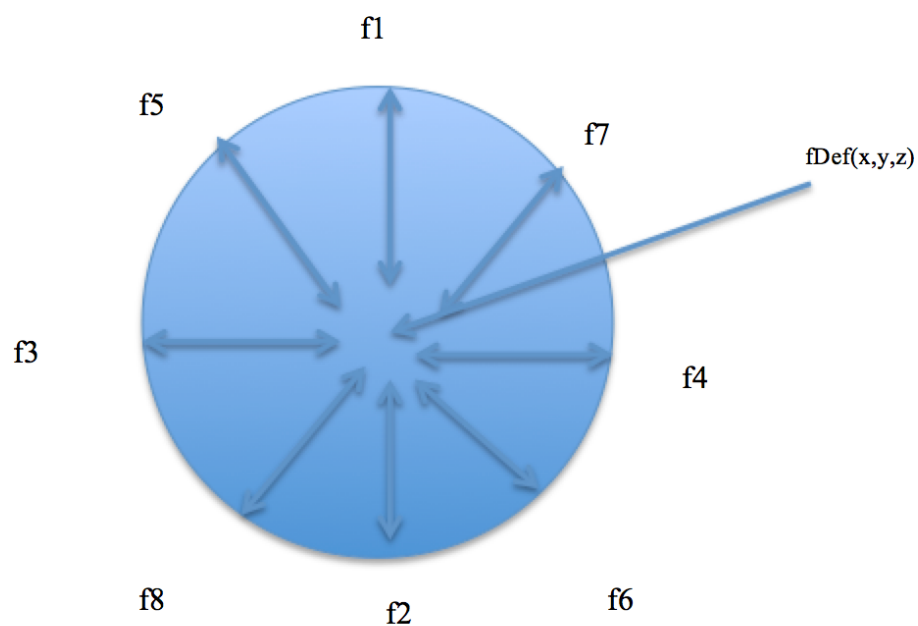


Figure 4.8 Forearm movement parameter in relation to the movement of the elbow joint

4.4.4 Upper Arm

The upper arm parameter refers to the movement of the upper arm in relation to the shoulder joint. We refer to the default resting position of our upper arm as our default position $uDef(x, y, z)$ and from here we propose that the upper arm which includes the elbow, the forearm, the wrist, the hand and the fingers as children nodes can move along 8 possible lines or paths within our signing space in order to articulate a manual sign. These eight upper arm movement parameters are further illustrated in Figure 4.9.

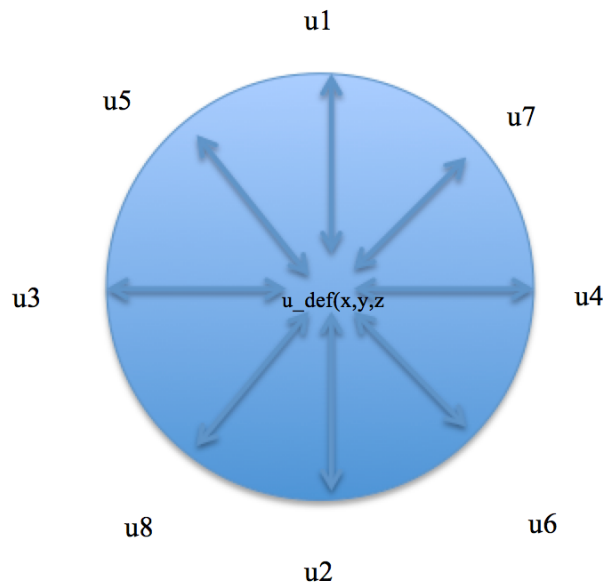


Figure 4.9 Upper arm movement parameter in relation to the shoulder joint

4.4.5 Arm Movement

The arm of a signer can move freely within 3D space, from making circular movements, which represents various morphological information to moving outward from the signer towards a locus or indeed towards a body anchored locus on the signer. These examples are just a small subset of the possibilities for arm movement. It is proposed that the driver for the movement of the arms is set on the wrist. The fingers can be manipulated and the handshape and orientation can be manipulated, but movement around 3D space is manipulated using the wrist driver. The arm movement parameter can be set using shape key default settings for any of the body anchored locations or signing space locations mapped out in section 4.4.7. The arm movement parameter can also be set to move toward a locus in 3D space.

4.4.6 Palm Orientation

This parameter refers to the orientation of the palm of the hand. Due to human skeletal constraints, the palm orientation parameter also accounts for the orientation of the wrist and the forearm as these are children nodes with regard to the orientation of the palm and are therefore constrained to reflect the same orientation as the palm of the hand. The orientation parameter allows us to rotate the palm of the hand, the wrist and the forearm around any of the x, y or z axis' within 3D

space, where x represents a value for the horizontal axis, y represents a value for the vertical axis and z represents a value for the axis that moves towards you or away from you (depth).

We set out by defining a default resting position of our palms in 3D space $pDef(x,y,z)$. This position sees the elbows tucked in by our sides and forearms pointing forward along the z -axis with the palms of the left hand and the right hand facing one another.

Based on this initial position and due to human skeletal constraints, the palm, wrist and forearm can rotate from this position anywhere from zero to 90 degrees in a clockwise direction and also from this position anywhere from zero to 90 degrees in an anti-clockwise direction around an axis. Depending on the initial positioning of the forearm parameter $f1$ to $f8$ (section 4.4.3) within 3D space, the rotation of the palm, wrist and forearm can rotate about any of the x , y or z axis $+x$ degrees or $-y$ degrees from this initial point. It is important to note that that this value may not always have a maximum value of 90 degrees as this amount is calculated based on previous positioning. If the palm is already at $+$ or $-$ 90 degrees then it will have reached a maximum value and therefore within normal human skeletal constraints cannot be rotated any further. The axis that the forearm will rotate around is calculated based on the positioning of the forearm in 3D space.

4.4.7 Location

The location or tab at which a sign is realised within 3D space is significant with regard to the syntax and semantics in ISL. Section 2.4.5.2 provides an example of ISL minimal pairs MY and STUPID, where the handshape used is the same and the feature that changes meaning is location. MY has the signer's chest as a location, whereas STUPID has the forehead as a location. Taking this into consideration and based on Brennan et al., (1984) our framework will take into account five different body anchored spatial locations: the head, the arms, the trunk, the hands and the spatial area around of the signer's body. For the purpose of computational modeling, we have divided the body anchored tabs into a separate category to the spatial signing space tabs. Each of the locations or tabs can be further divided into

individual subcategories. Figure 4.10 illustrates our proposed hierarchical division for the first two levels

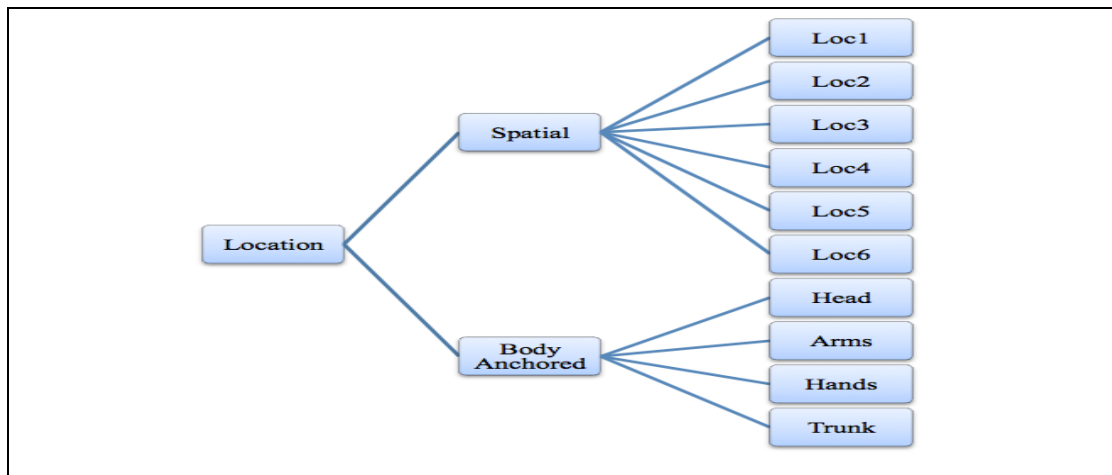


Figure 4.10 ISL tab categories with subcategories

Table 4.2 provides a list of the proposed subcategories of the body anchored locations illustrated in Figure 4.10. This provides us with parameters that allow us to cater for phenomena such as relative locational positioning within our framework where for example the *Head* body anchored location is further broken down into front and back of the head, temples, cheeks, ears nose, chin, mouth, forehead and also neck subcategories.

Due to the fact that within ISL an entity may be assigned a locus on the fingertips, with each fingertip then being activated as a locus that is co-referential with that entity, we must also consider these and assign the fingers of the hands as a subcategory of the hand tab category.

Table 4.2 Body anchored location categories with subcategories

Location	Subcategory
<BHEAD>head	hair, topHead, backHead, leftTemple, rightTemple, leftEar, rightEar, leftCheek, rightCheek, nose, chin, forehead, mouth, frontneck, backNeck, rightNeck, leftNeck
<BARM>arm	rightShoulder, leftShoulder, rightUpper, leftUpper, rightElbow, leftElbow, rightLower, leftLower, rightWristTop, leftWristTop, rightWristPalm, leftWristPalm, rightWristRightSide, RightWristLeftSide, LeftWristRightSide, LeftWristLeftSide
<BHAND>hand	rightBack, leftBack, rightPalm, leftPalm, rightIndexup, leftIndexUp, Lf1(x,y,z), Lf2(x,y,z), Lf3(x,y,z), Lf4(x,y,z), Lt(x,y,z), Rf1(x,y,z), Rf2(x,y,z), Rf3(x,y,z), Rf4(x,y,z), Rt(x,y,z)
<BTRUNK>trunk	chestCentre, chestHeart, tummy

4.4.8 Signing Space

Marshall and Sáfár (2004) propose that in computational terms the signing space should be subdivided into six distinct areas. Figure 4.11 illustrates the division of the signing space as proposed by Marshall and Sáfár (2004). We propose that we will further need to subdivide and extend this signing space to allow for a more granular division, which will lend itself more appropriately to our computational approach. We propose that within our architecture that we divide up the signing space into an upper, middle and lower tier. Within each tier we can then define x,y,z coordinates that can exist within an upper middle and lower level. This more granular approach to dividing up the signing space will aid us in catering for a fine-grained approach to positioning elements within the signing space, which is necessary in computational terms, which is essential for a more realistic articulation of an utterance and more fluent rendering of the ISL articulation.

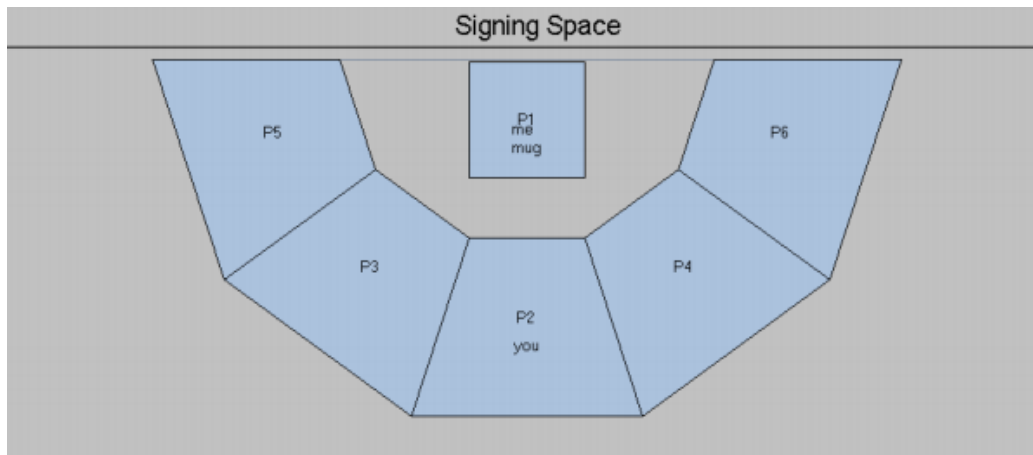


Figure 4.11 Signing space allocation map, Marshall and Sáfár (2004: 192)

Our proposed linguistically motivated computational framework for ISL, proposes six subcategories for location, similar to Marshall and Sáfár (ibid.), which are further applied across three distinct tiers within 3D space, an upper, a middle and a lower tier. Table 4.3 illustrates the five possible locations and the subcategories listed for these locations within ISL.

Table 4.3 ISL signing space categories with subcategory allocations

Location	Subcategories
Loc2	Loc2_up, Loc2_mid, Loc2_low
Loc3	Loc3_up, Loc3_mid, loc3_low
Loc4	Loc4_up, Loc4_mid, loc4_low
Loc5	Loc5_up, Loc5_mid, loc5_low
Loc6	Loc6_up, Loc6_mid, loc6_low

The sub-division of signing space into these three distinct tiers or areas, will allow for the fact that it may be necessary to sign or point in a upper level, directly in front of the signer (mid) or in a lower level. Figure 4.12 illustrates an allocation map specific to this framework. L1 represents the signer's body.

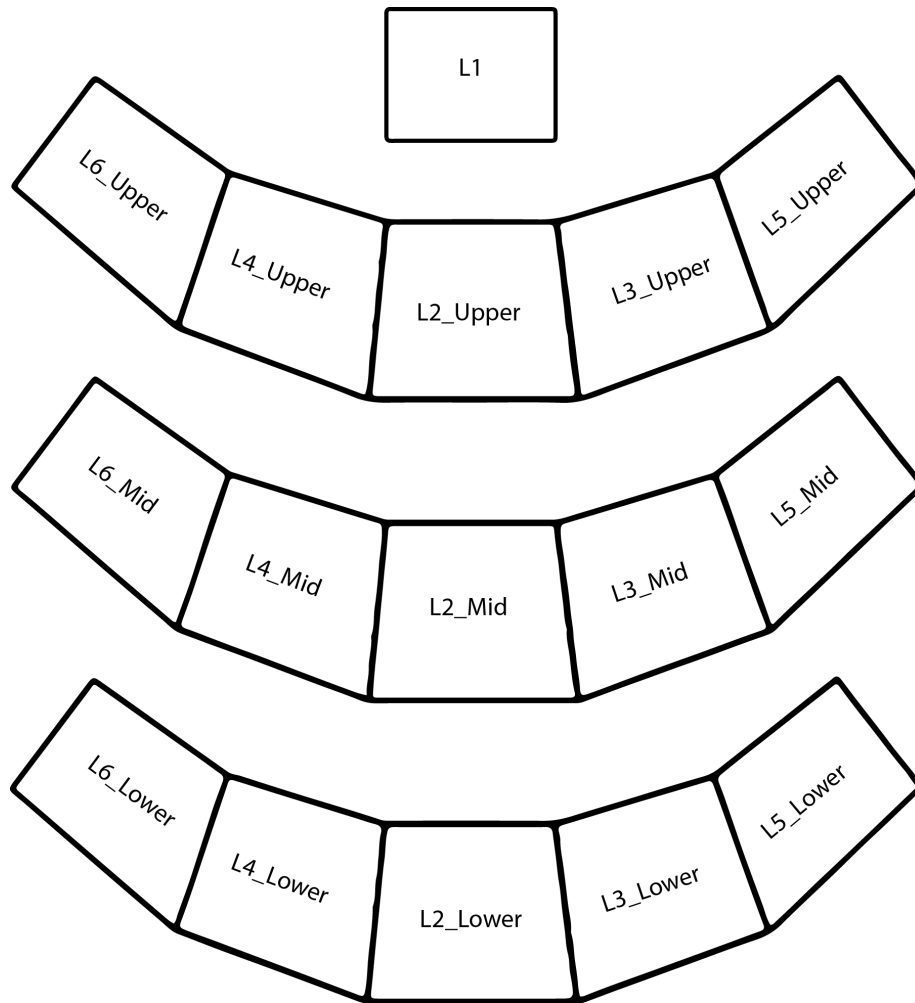


Figure 4.12 ISL computational signing space allocation map

The signing space above allows us to define (if necessary) a source x,y,z coordinate in any designated area of the map in Figure 4.2. It also allows us (if necessary) to define a goal x,y,z coordinate in any designated area of the map. This will enable us to capture the granular detail of location, essential to the fluent rendering of the articulation of an utterance in ISL.

4.5 Computational Phonological Parameters for ISL Non Manual Features

Table 4.4 illustrates the ISL NMF computational phonological parameters and the corresponding ISL phonemes relating to these. These ISL phonemes will be represented using morph targets, otherwise known as shape keys, within our computational framework. The phoneme scripts for transforming our signing avatar mesh will be passed as arguments to the various phonological parameters as

necessary depending on the articulation being realised. Temporal information with regard to the duration it takes for each individual phoneme to be articulated in seconds will be passed along with the script. Further to this, timing information with regard to the overall duration of the entire articulation, describing at which point in time within this that the phoneme is articulated in parallel with other units of grammatical description.

Table 4.4 Computational phonological parameters for ISL NMF

ISL NMF Phonological Parameter	ISL NMF Phoneme
<HEAD>Head	nod, shake, tilt_left, tilt_right, turn_left, turn_right, chin_chest, chin_L_shoulder, chin_R_shoulder
<EB>EyeBrow (left and right simultaneous)	neutral, frown, arch
<EL>EyeLids (left and right simultaneous)	neutral, wide, squint, blink, closed
<EG>EyeGaze(left and right simultaneous)	neutral, left, right, up, down, left_up, left_down, right_up, right_down, locus, follow r hand, follow l hand
<CHK>Cheek (left and right simultaneous) Blow can be left or right separately also.	suck_in, blow
<MTH>Mouth	neutral, open_wide, closed_tight, smile_teeth, smile_teeth_wide, smile_closed, round_open, round_closed
<TNG> ³ Tongue	in, out_pointed_1, out_pointed_2, out_pointed_3, out_round_1, out_round_2, out_round_3
<NSE>	crinkle, flare
<SHL>	neutral, up, down

4.6 Temporal Features

Vermeerbergen et al. (2007) outline the complexity of simultaneity within signed languages. Leeson and Saeed (2004, 2007) further provide evidence of this for ISL. As discussed in section 4.3, any given ISL phoneme, morpheme or lexeme may be realised simultaneously and in parallel along a timeline. The order or linear

³ With regard to the Tongue phonological parameter, the values 1, 2 and 3 in relation to protrusion define the percentage of the tongue, which will protrude past the lips. 1 represents 10%, 2 represents 60 % and 3 represents 100% protrusion.

sequence in which these units (distinct from one another) are realised along a timeline is significant with regard to the syntax and semantics of SL.

Taking this into consideration, we propose that relevant timing information parameters must be introduced and provided for within our proposed framework. The duration that it takes to articulate each individual phonological parameter and also the point at which each individual phonological parameter is articulated relative to the overall duration of an utterance is critical to the communication process. We propose that in order to cater for timing information in relation to the duration any given phonological parameter can be used across the larger timeline of an entire utterance that we must define two new parameters for use within our linguistically motivated computational framework. We will refer to these as the *event duration* parameter (EDtn) and *timeline* parameter (TLtn) respectively. The *eventDuration* and *timeLine* parameters will be used to allow us to synchronise the various NMF and MF phonological parameters across an ISL signed articulation.

4.6.1 Event Duration

It is proposed that a parameter, henceforth termed *event duration* will be utilised in our linguistically motivated computational framework, as a meta-data repository pertaining to timing or temporal information. The event duration parameter will be utilised as an attribute within our framework together with each distinct phonological parameter, both MF and NMF. It will function linguistically at the morphological/ phonological interface, defining the duration or time taken for any given MF or NMF phonological parameter to be realised. The visual gestural realisation of an ISL MF and NMF phonological parameter is considered to be an *event* within our computational framework. The realisation of each event has a specific duration bound to it. This can be referred to as an *event duration* (EDtn). This temporal parameter will play a central role within our framework in relation to the amount of time allowed for each distinct MF and NMF phonological parameter to realise various phonological and morphological content within an utterance. This parameter will be used to allow us to synchronise the timing information relating to when each distinct MF or NMF phonological parameter, providing information on when an event may execute along a larger timeline parameter. Due to the visual gestural nature of sign language and the fact that parameters for MFs and NMFs

may be articulated simultaneously along a timeline to articulate an utterance, the event duration parameter plays an essential role within the framework. The eventDuration (EDtn) parameter of each MF and NMF phonological parameter will be executed in relation to the timing information of the entire utterance or the timeline parameter (TLtn). The timeline parameter will be discussed in more detail in the following section.

While the eventDuration parameter (EDtn) and the timeline parameter (TLtn) have been identified and proposed here with regard to SL, it is possible that these parameters and Articulatory structure Level parameters may also have potential implications with regard to 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 communications one considers to be part of language”. However, it has become increasingly accepted in spoken language linguistics literature that gesture and non-verbal communication play an important role in face-to-face spoken language communication (Ní Chasaide and Gobl, 1990). Further research may well show that Articulatory Structure Level has implications for both SL and spoken language linguistics, particularly within the domain of prosody, gesture and non-verbal communication with regard to spoken language linguistics.

4.6.2 Timeline

A second temporal parameter, which must also be considered, is a *timeline* parameter (TLtn). Not to be confused with the event duration parameter, which defines the time taken to realise any given MF or NMF phonological parameter within an utterance, the *timeline* parameter refers to a linear timeline representing the overall time taken from the moment an ISL utterance begins until the moment an entire utterance or articulation is completed or terminates. An utterance refers in this case to an ISL lexeme, phrase or sentence that communicates something meaningful. The timeline parameter will play a central role within our computational framework as it is responsible for synchronisation and keeping track of the sequence in which each phonological parameter event will be realised. The timeline parameter will track temporal information to every phonological parameter defining at which point along the overall timeline any given phonological parameter

or event may be realised. This parameter will allow us to synchronise the order in which each parameter will be articulated and also allow for the concurrent or simultaneous articulation of parameters when this is necessary.

Due to the visual gestural modality of ISL within 3D space, the event duration and timeline parameters are central components of our computational framework, providing essential temporal information that is relevant and bound to every phonological parameter. These parameters will enable the realisation of a credible, plausible and comprehensible ISL utterance articulated in 3D space.

4.7 Qualia Structure for Lexical Meaning

Pustejovsky (1995) defines the Generative Lexicon (GL) as a theory of linguistic semantics, which focuses on the distributed nature of compositionality in natural language. Pustejovsky (1991a) reports that the qualia structure of a word specifies four aspects of its meaning. These are outlined in the Table 4.5.

Table 4.5 The four basic aspects of a words meaning, Pustejovsky (1991a: 418)

Aspects of word meaning
The relation between it and its constituent parts
That which distinguishes it within a larger domain (its physical characteristics)
Its purpose and function
Whatever brings it about

Table 4.6 illustrates Pustejovsky's proposal that lexical meaning could best be captured by assuming four levels of representation.

Table 4.6 Lexical meaning representation levels, Pustejovsky (1991a: 419)

Lexical Representation Level	Description
<i>Argument Structure</i>	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.
<i>Event Structure</i>	Identification of the particular event type (in the sense of Vendler (1967)) for a word or phrase: e.g. as state, process, or transition.
<i>Qualia Structure</i>	The essential attributes of an object as defined by the lexical item.
<i>Inheritance Structure</i>	How the word is globally related to other concepts in the lexicon.

In terms of GL theory, each of these four structures provides a different level of semantic expressiveness and representation needed for a computational theory of lexical semantics. Each level contributes different information, which allows for the composition of the semantics of a lexical item. Prior to GL theory, lexical decomposition theories assumed a fixed set of primitives with regard to a word and then operated within this set in an exhaustive fashion to capture the meaning of all words within a language. Lexical ambiguity was accounted for by adding more than one word entry into the lexicon. Pustejovsky (1991a: 1) proposed that:

“rather than assuming a fixed set of primitives, let us assume a fixed number of generative devices that can be seen as constructing semantic expressions”.

Qualia structures are defined by Pustejovsky as the modes of explanation associated with a word or phrase. Qualia provide a description of the meaning of lexical items in terms of four roles. Table 4.7 provides an outline of these.

Table 4.7 Qualia structure roles, Pustejovsky (1991a: 418)

Role	Description
Constitutive	Describing physical properties of an object, i.e. its weight, material as well as parts and components.
Agentive	Describing factors involved in the bringing about of an object, i.e. its creator or the causal chain leading to its creation.
Formal	Describing the properties that distinguish an object in a larger domain, i.e. orientation, magnitude, shape and dimensionality.
Telic	Describing the purpose or function of an object.

An example to illustrate the roles provided by Pustejovsky (1991a) and reinterpreted by Van Valin (2005) is provided in Example 4.1.

Example 4.1 Minimal semantic description for the noun “novel”

Novel (y)

Const: **narrative**(y)

Form: **book**(y), **disk**(y)

Telic: **do** (x, [**read** x,y])

Agentive: **artifact**(y), do (x, [**write** (x,y)] & INGR **exist** (y))

(Van Valin, 2005: 51, example 2.25)

4.8 Lexical Meaning for Irish Sign Language

Bearing in mind the computational phonological parameters necessary to represent an ISL utterance and taking into account Pustejovsky’s proposal (Pustejovsky, 1991a), that lexical meaning could best be captured by assuming four levels of representation, 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, the number of levels of lexical representation available within the GL framework should be extended from 4 levels to 5.

It is proposed that we must develop an entirely new level of representation for lexical meaning to capture the linguistic phenomena consistent with ISL in order to truly represent and accommodate ISL in linguistic terms. The computational phonological parameters which have been defined within this chapter, together with their respective subcategories must be represented in a new level of lexical representation for SL in particular to this research ISL. This new level of information structure will be referred to as *Articulatory Structure Level*.

Our proposed linguistically motivated computational framework shall utilise Articulatory Structure Level, which refers to the lexical representation of signed languages in which the essential (computational) phonological parameters of an object as defined by the lexical item are captured.

Table 4.8 illustrates the four levels of lexical meaning proposed by Pustejovsky (1991a) and the additional level proposed in order to cater for the linguistic phenomena consistent with ISL. Our linguistically motivated computational framework shall henceforth be termed the Sign_A framework, with the ‘A’ in this term representing Articulatory Structure Level. Table 4.8 provides the five levels of lexical representation for SL.

Table 4.8 Five levels of lexical representation for Sign Language

Lexical Representation Level	Description
<i>Argument Structure</i>	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.
<i>Event Structure</i>	Identification of the particular event type (in the sense of Vendler (1967)) for a word or phrase: e.g. as state, process, or transition.
<i>Qualia Structure</i>	The essential attributes of an object as defined by the lexical item.
<i>Inheritance Structure</i>	How the word is globally related to other concepts in the lexicon.
<i>Articulatory Structure</i>	The essential (computational) phonological parameters of an object as defined by the lexical item.

Table 4.9 following provides an overview of our proposed computational phonological parameters for ISL MFs and NMFs. These parameters will be catered

for within the Articulatory Structure Level, which represents the essential (computational) phonological parameters of an object as defined by the lexical item. These parameters will be used to account for various linguistic phenomena pertaining to ISL manual and NMFs, which are necessary to adequately represent ISL within a computational framework.

Table 4.9 ISL computational phonological parameters and their corresponding subcategories

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))
Hand Movement <HM>	w1(xi,yi,zi).....w1(xn,yn,zn) w2 (xi,yi,zi).....w2 (xn,yn,zn) w3 (xi,yi,zi).....w3 (xn,yn,zn) w4 (xi,yi,zi).....w4 (xn,yn,zn) eventDuration(EDti, EDtn) timeline(TLti, TLtn) wDef((w1....w4, xi,yi,zi: xn,yn,zn), eventDuration(EDti, EDtn), timeline(TLti, TLtn), hsDef)
Palm Orientation <PO>	pO(xi,yi,zi).... pO(xn,yn,zn) pODef(xi,yi,zi: xn,yn,zn, eventDuration(EDti, EDtn), timeline(TLti, TLtn), hsDef, wDef)
Arm Movement <AM>	locus(xi,yi,zi).....locus(xn,yn,zn) eventDuration(EDti, EDtn) timeline(TLti, TLtn) aMDef((locus xi,yi,zi: xn,yn,zn SSLDef: SSLDef circular), eventDuration(EDti, EDtn), timeline(TLti, TLtn), hsDef, wDef, pODef, fADef, uADef)

Forearm <FA>	f1(xi,yi,zi).... f1(xn,yn,zn) f2(xi,yi,zi).... f2(xn,yn,zn) f3(xi,yi,zi).... f3(xn,yn,zn) f4(xi,yi,zi).... f4(xn,yn,zn) f5(xi,yi,zi).... f5(xn,yn,zn) f6(xi,yi,zi).... f6(xn,yn,zn) f7(xi,yi,zi).... f7(xn,yn,zn) f8(xi,yi,zi).... f8(xn,yn,zn) eventDuration(EDti, EDtn) timeline(TLti, TLtn) fADef((f1....f8, xi,yi,zi: xn,yn,zn), eventDuration(EDti, EDtn), timeline(TLti, TLtn), hDef,wDef, poDef)
Upper Arm <UA>	u1(xi,yi,zi).... u1(xn,yn,zn) u2(xi,yi,zi).... u2(xn,yn,zn) u3(xi,yi,zi).... u3(xn,yn,zn) u4(xi,yi,zi).... u4(xn,yn,zn) u5(xi,yi,zi).... u5(xn,yn,zn) u6(xi,yi,zi).... u6(xn,yn,zn) u7(xi,yi,zi).... u7(xn,yn,zn) u8(xi,yi,zi).... u8(xn,yn,zn) eventDuration(EDti, EDtn) timeline(TLti, TLtn) uADef((u1....u8, xi,yi,zi: xn,yn,zn), eventDuration(EDti, EDtn), timeline(TLti, TLtn), hDef,wDef, poDef, fDef)
Event duration <EDtn>	(EDti, EDtn)
Timeline <TLtn>	(TLti, TLtn)
Signing space location <SSL>	L1_upper, L2_upper, L3_upper, L4_upper, L5_upper, L6_upper, L1_mid, L2_mid, L3_mid, L4_mid, L5_mid, L6_mid, L1_lower, L2_lower, L3_lower, L4_lower, L5_lower, L6_lower. eventDuration(EDti, EDtn) timeline(TLti, TLtn) SSLDef((⁴x), eventDuration(EDti, EDtn), timeline(TLti, TLtn))
Body anchored head <BA_h>	hair, topHead, backHead, leftTemple, rightTemple, leftEar, rightEar, leftCheek, rightCheek, nose, chin, forehead, mouth, frontneck, backNeck, rightNeck, leftNeck eventDuration(EDti, EDtn) timeline(TLti, TLtn)

⁴ x in this instance refers to any chosen location from the above parameters representing the various signing space locations illustrated in figure 4.4.

	BA_hDef ((⁵ x), eventDuration (EDti, EDtn), timeline (TLti, TLtn))
Body anchored arm <BA_a>	rightShoulder, leftShoulder, rightUpper, leftUpper, rightElbow, leftElbow, rightLower, leftLower, rightWristTop, leftWristTop, rightWristPalm, leftWristPalm, rightWristRightSide, RightWristLeftSide, LeftWristRightSide, LeftWristLeftSide eventDuration (EDti, EDtn) timeline (TLti, TLtn) BA_aDef ((⁶ x), eventDuration (EDti, EDtn), timeline (TLti, TLtn))
Body anchored hand <BA_hand>	rightBack, eventDuration (EDti, EDtn), timeLine (TLti, TLtn) leftBack, eventDuration (EDti, EDtn), timeLine (TLti, TLtn) rightPalm, eventDuration (EDti, EDtn), timeLine (TLti, TLtn) leftPalm, eventDuration (EDti, EDtn), timeLine (TLti, TLtn) rightIndexup, eventDuration (EDti, EDtn), timeLine (TLti, TLtn) leftIndexUp, eventDuration (EDti, EDtn), timeLine (TLti, TLtn) Lf1(x,y,z), eventDuration (EDti, EDtn), timeLine (ti, tn) Lf2(x,y,z), eventDuration (EDti, EDtn), timeLine (TLti, TLtn) Lf3(x,y,z), eventDuration (EDti, EDtn), timeLine (TLti, TLtn) Lf4(x,y,z), eventDuration (EDti, EDtn), timeLine (TLti, TLtn) Lt(x,y,z), eventDuration (EDti, EDtn), timeLine (TLti, TLtn) Rf1(x,y,z), eventDuration (EDti, EDtn), timeLine (TLti, TLtn) Rf2(x,y,z), eventDuration (EDti, EDtn), timeLine (TLti, TLtn) Rf3(x,y,z), eventDuration (EDti, EDtn), timeLine (TLti, TLtn) Rt(x,y,z), eventDuration (EDti, EDtn), timeLine (TLti, TLtn) BA_handDef ((⁷ x), eventDuration (EDti, EDtn), timeline (TLti, TLtn))
Body anchored trunk <BA_t>	chestCentre, eventDuration (EDti, EDtn), timeLine (TLti, TLtn) chestHeart, eventDuration (EDti, EDtn), timeLine (TLti, TLtn) tummy, eventDuration (EDti, EDtn), timeLine (TLti, TLtn) BA_t ((⁸ x), eventDuration (EDti, EDtn), timeline (ti,tn))
Head	nod (intensity), eventDuration (EDti, EDtn), timeLine (TLti,

⁵ x in this instance refers to any chosen location from the above parameters representing the various body anchored head signing space locations.

⁶ x in this instance refers to any chosen location from the above parameters representing the various signing space locations on the signer's arm.

⁷ x in this instance refers to any chosen location from the above parameters representing the various signing space locations on the signer's arm.

⁸ x in this instance refers to any chosen location from the above parameters representing the various signing space locations on the signer's arm.

<Head>	TLtn) shake(intensity), eventDuration(EDti, EDtn), timeLine(TLti, TLtn) tiltL, eventDuration(EDti, EDtn), timeLine(TLti, TLtn) tiltR, eventDuration(EDti, EDtn), timeLine(TLti, TLtn) turnL, eventDuration(EDti, EDtn), timeLine(TLti, TLtn) turnR, eventDuration(EDti, EDtn), timeLine(TLti, TLtn) Head_Def(⁹x), eventDuration(EDti, EDtn), timeline(TLti, TLtn))
Eyebrows <EB>	neutral, eventDuration(EDti, EDtn), timeLine(TLti, TLtn) frown, eventDuration(EDti, EDtn), timeLine(TLti, TLtn) arch, eventDuration(EDti, EDtn), timeLine(TLti, TLtn) EB_Def(¹⁰x), eventDuration(EDti, EDtn), timeline(TLti, TLtn))
Eyelid <EL>	neutral, eventDuration(EDti, EDtn), timeLine(TLti, TLtn) openWide, eventDuration(EDti, EDtn), timeLine(TLti, TLtn) squint, eventDuration(EDti, EDtn), timeLine(TLti, TLtn) blink, eventDuration(EDti, EDtn), timeLine(TLti, TLtn) closed eventDuration(EDti, EDtn), timeLine(TLti, TLtn) EL_Def(¹¹x), eventDuration(EDti, EDtn), timeline(TLti, TLtn))
Eye gaze <EG>	neutral, eventDuration(EDti, EDtn), timeLine(TLti, TLtn) left, eventDuration(EDti, EDtn), timeLine(TLti, TLtn) right, eventDuration(EDti, EDtn), timeLine(TLti, TLtn) up, eventDuration(EDti, EDtn), timeLine(TLti, TLtn) down, eventDuration(EDti, EDtn), timeLine(TLti, TLtn) left_up, eventDuration(EDti, EDtn), timeLine(TLti, TLtn) left_down, eventDuration(EDti, EDtn), timeLine(TLti, TLtn) right_up, eventDuration(EDti, EDtn), timeLine(TLti, TLtn) right_down, eventDuration(EDti, EDtn), timeLine(TLti, TLtn) locus(signingSpaceLocation) eventDuration(EDti, EDtn), timeLine(TLti, TLtn)

⁹ x in this instance refers to any chosen location from the above parameters representing the various signing space locations on the signer's arm.

¹⁰ x in this instance refers to any chosen location from the above parameters representing the various signing space locations on the signer's arm.

¹¹ x in this instance refers to any chosen location from the above parameters representing the various signing space locations on the signer's arm.

	followRHand, eventDuration(EDti, EDtn), timeLine(TLti, TLtn) followLHand, eventDuration(EDti, EDtn),timeLine(TLti,TLtn) EG_Def((¹²x), eventDuration(EDti, EDtn), timeline(TLti, TLtn))
Cheeks ¹³ <CHK> <RCHK> <LCHK>	suck_in, eventDuration(EDti, EDtn), timeLine(ti, tn) blow,eventDuration(EDti, EDtn), timeLine(ti, tn) CHK_Def((¹⁴ x), eventDuration(EDti, EDtn), timeline(ti,tn)) RCHK_Def((¹⁵ x), eventDuration(EDti, EDtn), timeline(ti,tn)) LCHK_Def((¹⁶x), eventDuration(EDti, EDtn), timeline(TLti, TLtn))
Mouth <MTH>	neutral, eventDuration(EDti, EDtn), timeLine(TLti, TLtn) open_wide, eventDuration(EDti, EDtn), timeLine(TLti, TLtn) closed_tight, eventDuration(EDti, EDtn), timeLine(TLti, TLtn)) smile_teeth, eventDuration(EDti, EDtn), timeLine(TLti, TLtn) smile_teeth_wide, eventDuration(EDti, EDtn), timeLine(TLti, TLtn) smile_closed, eventDuration(EDti, EDtn), timeLine(TLti, TLtn)) round_open, eventDuration(EDti, EDtn), timeLine(TLti, TLtn) round_closed, eventDuration(EDti, EDtn), timeLine(TLti, TLtn)) MTH_Def((¹⁷x), eventDuration(EDti, EDtn), timeline(TLti, TLtn))

¹² x in this instance refers to any chosen location from the above parameters representing the various signing space locations on the signer's arm.

¹³ The cheek NMF *blow* may be produced by both cheeks simultaneously or by the right or left cheek singly.

¹⁴ x in this instance refers to any chosen location from the above parameters representing the various signing space locations on the signer's arm.

¹⁵ x in this instance refers to any chosen location from the above parameters representing the various signing space locations on the signer's arm.

¹⁶ x in this instance refers to any chosen location from the above parameters representing the various signing space locations on the signer's arm.

¹⁷ x in this instance refers to any chosen location from the above parameters representing the various signing space locations on the signer's arm.

Tongue <TNG>	in, out_pointed_1, eventDuration(EDti, EDtn), timeLine(TLti, TLtn) out_pointed_2, eventDuration(EDti, EDtn), timeLine(TLti, TLtn) out_pointed_3, eventDuration(EDti, EDtn), timeLine(TLti, TLtn) out_round_1, eventDuration(EDti, EDtn), timeLine(TLti, TLtn) out_round_2, eventDuration(EDti, EDtn), timeLine(TLti, TLtn) out_round_3, eventDuration(EDti, EDtn), timeLine TLti, TLtn) TNG_Def((¹⁸x), eventDuration(EDti, EDtn), timeline(TLti, TLtn))
Nose <NSE>	crinkle, eventDuration(EDti, EDtn), timeLine(TLti, TLtn) flare, eventDuration(EDti, EDtn), timeLine(TLti, TLtn) NSE_Def((¹⁹x), eventDuration(EDti, EDtn), timeline(TLti, TLtn))
Shoulder ²⁰ <SHL> <RSHL> <LSHL>	neutral, eventDuration(EDti, EDtn), timeLine(TLti, TLtn) up, eventDuration(EDti, EDtn), timeLine(TLti, TLtn) down, eventDuration(EDti, EDtn), timeLine(TLti, TLtn) SHL_Def((²¹x), eventDuration(EDti, EDtn), timeline(TLti, TLtn)) RSHL_Def((²²x), eventDuration(EDti, EDtn), timeline(TLti, TLtn)) LSHL_Def((²³x), eventDuration(EDti, EDtn), timeline(TLti, TLtn))

It is proposed that using this model and the proposed new level of lexical representation, the phonological parameters for both MFs and NMFs consistent with ISL can be represented and referred to within the lexicon, thereby allowing for the development of our lexicon architecture, as it is sufficiently flexible and robust to accommodate ISL at a semantic, syntactic and pragmatic level.

¹⁸ x in this instance refers to any chosen location from the above parameters representing the various signing space locations on the signer's arm.

¹⁹ x in this instance refers to any chosen location from the above parameters representing the various signing space locations on the signer's arm.

²⁰ The shoulder NMF may be produced by both shoulders simultaneously or by the right or left shoulder singly.

²¹ x in this instance refers to any chosen location from the above parameters representing the various signing space locations on the signer's arm.

²² x in this instance refers to any chosen location from the above parameters representing the various signing space locations on the signer's arm.

²³ x in this instance refers to any chosen location from the above parameters representing the various signing space locations on the signer's arm.

4.9 Summary

In this chapter we addressed RQ2. We defined the various computational phonological parameters that are necessary to represent ISL MF and NMF in computational linguistic terms. On further investigation we re-defined the signing space for ISL in terms of our humanoid avatar and the 3D space in which it is encompassed.

We further defined new body anchored phonological parameters and we also defined parameters relating to time, namely *timeline* and *eventDuration*. We looked to Pustejovsky's theory of the Generative Lexicon (GL) and proposed that with a view to representing SL, in particular ISL, the GL theory of Lexical Representation should be extended from 4 levels to 5 levels.

It was proposed that we must develop an entirely new level of representation for lexical meaning to capture the linguistic phenomena consistent with ISL in order to truly represent and accommodate ISL in linguistic terms. This new level of information structure will be referred to as *Articulatory Structure Level*. Articulatory structure level will be utilised to refer to the lexical representation of signed languages in which the essential (computational) phonological parameters of an object as defined by the lexical item are captured.

It is important to mention at this juncture the implications that Articulatory Structure Level 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. As mentioned previously in section 4.6.1, 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).

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 the development of a linguistically motivated computational framework for ISL, 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.

5. Irish Sign Language Verbs

5.1 Introduction

In this chapter we address RQ3. We provide a definition for the structure of lexical entries for ISL verbs. We initially investigate the linguistics of ISL verbs, starting with Padden's traditional approach to classifying SL verbs (Padden, 1988). We proceed by investigating more recent advances in the literature in this area. In order to provide background on our analysis of ISL verbs we must first outline the morphological and grammatical information that can be found in ISL verbs. We look here to grammatical categories of tense, aspect, manner and number in ISL and describe how these inflectional features are marked in visual gestural modality. We provide an account of how ISL verbs may be represented within the lexicon in linguistically motivated computational terms. We investigate the possibility of extending Pustejovsky's theory of lexical semantics to account for the linguistic phenomena presented by ISL verbs. We utilise RRG, and the Event Visibility Hypothesis (EVH) (Wilbur, 2008) in the development of our proposed lexicon architecture.

5.2 ISL Verb Classification

Spoken languages display multiple devices for making clear the relationships between verbs and their arguments, including discourse patterns, word order, case morphology on nouns, and 'person marking', which can include agreement morphology on verbs as well as (possibly weak or clitic) pronouns (Lillo-Martin and Meier 2011, Siewierska 2004). Within the field of spoken languages, a wealth of research has been carried out in relation to verb categorisation and classification. Levin (1993) provides a comprehensive taxonomy of over 3000 verbs from spoken English based on the properties of shared meaning and behavior. Levin takes the view that the meaning of a verb affects its syntactic behavior and provides us with numerous verb classes by distinguishing verbs with similar syntactic behavior.

As discussed in chapter 2, verb classification within SL is traditionally described according to Padden's classical tripartite classification of verbs based on American Sign Language (ASL) (Padden, 1988). The original theory has subsequently been

revisited, following Padden's observation, which was in most cases universally accepted. SL verbs may be described as falling into one of three categories: *plain* verbs, *spatial* verbs and *agreeing* verbs. *Plain verbs* are verbs that constitute the default semantic class within ASL. 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. *Agreeing verbs*, which agree with the subject and/or object, are a class of verb that denote transfer and are said to encode the syntactic role of the arguments, as well as their person and number features, by the direction of the movement of the hands and the orientation of the palms. Agreeing verb affixes show agreement with person or location. *Spatial verbs* are verbs that denote motion and location in space. Spatial verbs encode the locations of locative arguments, (the source and the goal) based on the direction of movement of the hands. The shape of the path movement the hands are tracing is said to often depict the shape of the path that an object traverses in space. McDonnell (1996) provides a comprehensive investigation of verb categories in ISL. McDonnell (ibid.) found that ISL displayed similar phenomena to Padden(1988) in terms of plain verbs and agreement verbs of location and of person. The following sub-sections provide further information on these SL verb classes.

5.2.1 Plain Verbs

Plain or unmarked verbs are seen as the default semantic verb class in SL and they do not move through space to show grammatical information. Any information regarding person or number needs to be given separately. Many plain verbs are made using the body as the location, however, this is a generalisation and not always the case as identified by Sutton-Spence and Woll (1999). Sutton-Spence and Woll (ibid.) provide the following list of body-anchored plain verbs in BSL: LIKE, LOVE, THINK, KNOW, SMOKE, UNDERSTAND, FEEL, SWEAR, WANT. Other BSL verbs, which are also plain but not body-anchored are: SWIM, RIDE-A-BICYCLE, RUN and RESEARCH. Manner and aspect are marked on plain verbs in BSL by the speed of repetition and also by the use of NMF.

Examples of ISL plain verbs are: THINK, EAT, KNOW, LIKE, LOVE, DANCE, WANT, UNDERSTAND. The following figures provides two examples of the ISL plain verbs from the SOI corpus. Figure 5.1 illustrates the ISL verb THINK and Figure 5.2 illustrates the verb LOVE.



Figure 5.1 ISl plain verb THINK: SOME BOY THINK, Signs of Ireland Corpus Noeleen (03) Personal Stories (Dublin)

‘Some boys think’



Figure 5.2 ISL plain verb LOVE: (I) LIKE (IT), Signs of Ireland Corpus Noeleen (03) Personal Stories (Dublin)

‘(I) love (it (my job))’

On investigation of verb categories in ISL, McDonnell (2006: 116) provides evidence that ISL plain verbs do not take affixes which mark for agreement with person or location. McDonnell (ibid.) also provides evidence that ISL plain verbs are typically contact or body anchored signs. McDonnell (ibid.) also notes that ISL plain verbs typically occur within semantically related field “and there is often a motivated relationship between the forms which these verbs take and their meanings”. Examples provided for verbs of emotion, which occur in the chest/sternum area include LIKE, FEEL, BE_ANGRY, HATE, HAPPY and BE-FRUSTRATED.

According to O'Baoill and Matthews (2000: 124) the main characteristics of ISL plain verbs are:

- (1) They do not take personal inflection, that is they require separate signs to indicate person.
- (2) Their place of articulation is fixed
- (3) They have a set of common body contact signs

5.2.2 Person Agreement Verbs

The area of verb agreement within the field of SL linguistics is still largely contested and currently there is no universal acceptance of any given hypothesis on this subject. Agreement verbs allow the signer to indicate the subject and the object by changing the direction of the movement of the sign. Mathur and Rathmann (2012) identify the occurrence of verb agreement in many SL's, including, but not limited to, ASL (Padden 1983), Argentine Sign Language (Massone/Curiel 2004), Australian Sign Language (Johnston/Schembri 2007), Brazilian Sign Language (Quadros 1999), British Sign Language (Sutton-Spence and Woll 1999), Catalan Sign Language (Quer/Frigola 2006), German Sign Language (Rathmann 2000), Greek Sign Language (Sapountzaki 2005), Indo-Pakistani Sign Language (Zeshan 2000), Israeli Sign Language (Meir 1998b), Japanese Sign Language (Fischer 1996), Korean Sign Language (Hong 2008), Sign Language of the Netherlands (Bos 1994; Zwitserlood/Van Gijn 2006), and Taiwanese Sign Language (Smith 1990). Contrary to this view Liddell (2003) argues that directing verbs in space has nothing to do with an agreement process and is not inflectional.

McDonnell (1996) reports that there is evidence that agreement verbs occur within ISL and these can be further subdivided into the two distinct groups of person agreement and location agreement. Leeson and Saeed (2012) also identify that verb agreement occurs within ISL. Similar to McDonnell (1996) they identify that agreement verbs can be further sub-divided into those that show *person agreement* with subject/actor or object/undergoer and those whose affixes are controlled by locations (*locative agreement*). ISL person agreement or syntactic agreement may be defined according to the following subcategories: single, double, backwards and reciprocal.

Within agreement verbs, the verb may manifest itself in different ways depending on its phonological shape. The various ways of manifesting agreement verbs has sometimes been subsumed in the literature under the term ‘directionality’ (Mathur and Rathmann, 2012). However, Sutton-Spence and Woll (1999) also observe that agreement verbs include verbs that are sometimes called directional verbs, however, the term “directional” focuses on the form of the verb (e.g. where it moves), whereas, the term “agreement” focuses on the morphological information in the verb. With regard to the development of a linguistically motivated computational framework the approach of McDonnell (1996) and Leeson and Saeed (2012) lends itself well in terms of the signer indicating the subject and the object by changing the direction of the movement of the sign. We refer to this type of phenomena in ISL as agreement therefore, henceforth use the term “agreement” when we refer to this phenomenon.

5.2.2.1 Single Agreement

Single agreement verbs show agreement with only one argument. The onset is uninflected and therefore there is no agreement with the subject/actor. The offset on the other hand agrees with the object/argument. Examples of single agreement ISL verbs are SAY-TO, SEE (McDonnell 1996) and TELL-ME (Leeson and Saeed 2012). Mathur and Rathmann (2012) identify the ASL verb TELL as an example of ASL single agreement, which marks only the indirect/direct object (Meier, 1982).

5.2.2.2 Double Agreement

Double agreement occurs when the onset of the verb agrees with the actor/subject argument and the offset corresponds to the undergoer/object argument. Within ISL the verbs IGNORE, ACCUSE and GIVE can be used as an example of a double agreement verb McDonnell (1996).

5.2.2.3 Backward Agreement

Backward agreement is another type of person agreement verb, which occurs where the relevant participants are inflectionally marked, but the affix positioning is reversed. With backward agreement verbs, the verb begins at the location of the object/undergoer and moves towards the location of the subject/actor. Quadros and

Quer (2006) observe that unlike “regular” agreement verbs, most backwards verbs are not ditransitive. They provide examples of ASL verbs to defend this deduction. ASL examples are COPY, EXTRACT, INVITE, MOOCH, STEAL, TAKE, TAKE-ADVANTAGE-OF, TAKE-OUT, GRAB, LIE-TO. Meir (1998) provides examples to defend this approach also. Israeli SL examples provided by Meir (ibid.) are: COPY, TAKE, CHOOSE, INVITE, TAKE-ADVANTAGE-OF, ADOPT, INHERIT, IMITATE, SUMMON, IDENTIFY-WITH. McDonnell (1996) provides evidence that backward agreement occurs within ISL and provides the verb CHOOSE as an example of this.

5.2.2.4 Reciprocal Agreement

Leeson (2001) identifies reciprocal verbs as another type of person agreement verb in ISL. Leeson and Saeed (2012) draw from Leeson (ibid.) with regard to reciprocal verbs in ISL and provide an example of CONSULT, which Leeson and Saeed (ibid.) point out is frequently glossed as DISCUSS. The morphological markers of both actor and undergoer occur on both hands indicating the dual or reciprocal nature of the verb. McDonnell (1996) provides the verbs CONSULT and ARGUE as examples of reciprocal agreement in ISL.

The following figures identified by Leeson and Saeed (2012) and taken from the SOI corpus, illustrate single, double, backwards and reciprocal person agreement verbs in ISL.

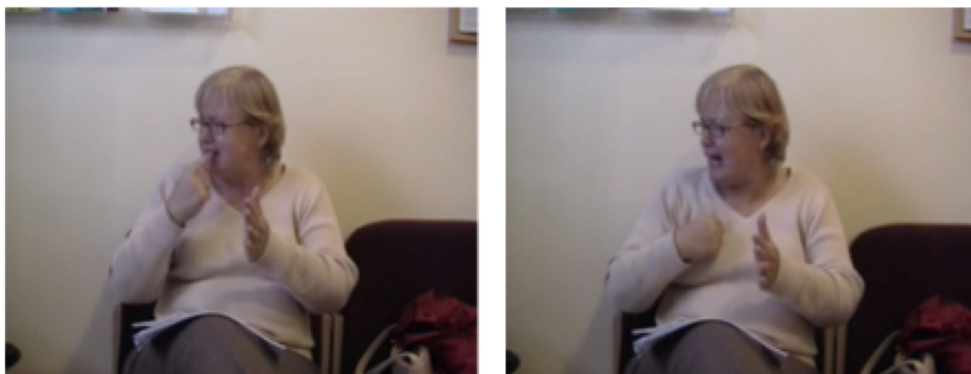


Figure 5.3 Single agreement verb TELL-ME: '(the tour guide) told me', Signs of Ireland Corpus Mary (33) Personal Stories (Galway), Leeson and Saeed (2012: 98, Example 5.7)

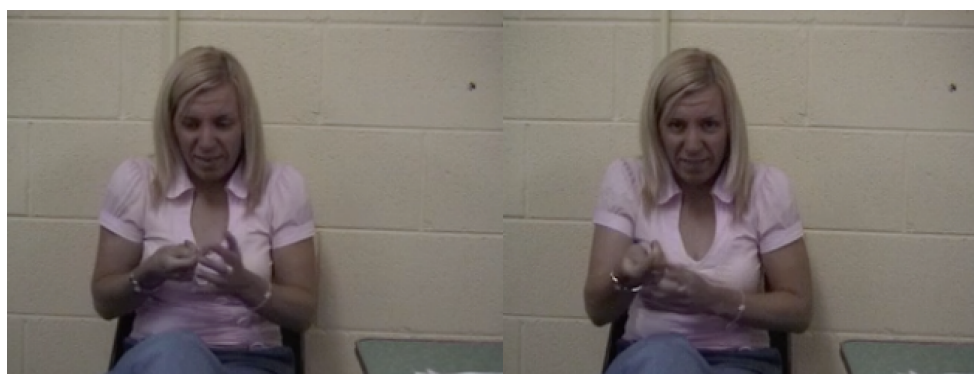


Figure 5.4 Double agreement verb GIVE: '(I) gave (the dog)(food)', Signs of Ireland Corpus Rebecca (38) Personal Stories (Waterford), Leeson and Saeed (2012: 97, Example 5.4)



Figure 5.5 Backward agreement verb CHOOSE: 'I chose/picked (someone/something)', Signs of Ireland Corpus Kevin (17) Personal Stories (Dublin) , Leeson and Saeed (2012: 98, Example 5.6)



Figure 5.6 Reciprocal agreement verb DISCUSS: 'We discussed the issue', Signs of Ireland Corpus Annie (26) Personal Stories (Wexford), Leeson and Saeed (2012: 97, Example 5.5)

5.2.3 Locative Agreement Verbs

Locative agreement verbs on the other hand, are verbs that are morphologically linked to locations rather than participants. Leeson and Saeed (2012) describe how in semantic terms locative agreement agrees with the source, goal or location, rather than actor or undergoer and that locative agreement provides the location of an entity or the path of its movement. McDonnell (1996) identifies a subclass of locative agreement within ISL. This agreement marks agreement with specific locations on the body as opposed to specific locations in space. Examples are: SLAP and also LICK-MY FACE, where a signer is telling how a boy at the zoo licks a boy's face.

5.2.4 Non-Manual Agreement Markers

Mathur and Rathmann (2012), identify Aarons et al., (1992); Bahan (1996); Neidle et al., (2000), and the proposal that an optional form of non-manual agreement may occur within SL. This may manifest itself as a change in head tilt and eye gaze co-occurring with the verb phrase. Thompson, Emmorey, and Kluender (2006) conducted an eye-tracking study to evaluate these claims and in conclusion found that since eye-gaze did not consistently occur with plain verbs (eye gaze was directed towards the object referent for only 11% of plain verbs), that it does not obligatorily mark object agreement.

5.2.5 Spatial Verbs

Padden (1988) describes spatial verbs as a class of verbs denoting motion and location in space. Spatial verbs encode the locations of locative arguments, the

source and the goal based on the direction of movement of the hands. The shape of the path movement the hands are tracing is said to often depict the shape of the path that an object traverses in space.

5.3 ISL Auxillary Verbs and Grammatical Items

Similar to spoken languages, ISL provides examples of transitive, intransitive and ditransitive main or lexical verbs. Auxiliary verbs are also found in ISL and stand in front of a main verb to convey distinctions of tense, modality and aspect. Leeson and Saeed (2012) identify CAN, FINISH, NEED, MUST, SHOULD and WILL as ISL auxiliary verbs.

5.3.1 Tense

Spoken English verbs show when an event occurs by adding information about past and present morphologically. In spoken English, we can use expressions of intent or lexical time markers like “next week” or “later” combined with the present tense to refer to the future (Sutton-Spence and Woll (1999)). Sign language verbs, just like verbs in many spoken languages, generally do not inflect for tense (Friedman 1975, Cogen 1977). Rather, tense is expressed by means of adverbials, which frequently make use of so-called ‘time lines’. It has been suggested for ASL and Italian Sign Language (LIS) that at least some verbs may inflect for tense be it by means of manual or non-manual modulations (Pfau et al., 2012). Sutton-Spence and Woll (1999), identify, that like English, BSL uses base verb forms with other separate lexical time markers e.g. TOMORROW, similar to spoken English. BSL also uses similar devices to refer to past and present, however, there is no evidence to show that BSL verbs contain morphological information to locate an event in time relative to the present.

Leeson and Saeed (2012) also find that there is no evidence to show that tense is marked morphologically on verbs in ISL. They do note however, that aspect allows speakers to relate situations in time with the view of being complete or incomplete.

5.3.2 Aspect

Leeson and Saeed (2012) describe aspect as an important inflectional category in ISL. Although tense is not marked morphologically on verbs in ISL, aspect allows

speakers to relate situations in time with the view of being complete or incomplete. Leeson and Saeed describe how ISL shows similarities in findings with regard to aspectual morphology in ASL, which were identified by Klima and Bellugi (1979). Similar to ASL, ISL utilises modifications to the movement parameter to articulate aspectual marking. However, reduplication is particularly significant with regard to aspectual marking within ISL. Different verb types correspond to different dynamic situations. Leeson and Saeed describe an aspectually modified variant of the ISL punctual verb KNOCK. In this case iterative or repetitive aspect interacting with the verb produces a different interpretation. Typically, within ISL, the verb KNOCK would have two repetitions associated with it. In the case identified by Leeson and Saeed, four repetitions signifies an aspectually modified variant of the verb, which implies that the knocking occurred repeatedly and with urgency. The movement parameter involves a straight line from close to the signer to the locus associated with the object (in this case a door). Leeson and Saeed also identify this “straight-line movement motif” repeated in other punctual verbs, for example HEART-BEATING +++++ (with multiple reiterations of the sign).

Leeson and Saeed (2012) also identify the imperfective aspectual modification of durational verbs in ISL. In the case of the verb CRY, the inflection is articulated by a repeated circular movement. The meaning communicated is of the extended duration of the event. Figure 5.7 illustrates that the subject cried over a long period of time and the NMF communicate that the subject was distressed. Perfective aspect marking has also been identified in ISL by the use of the verb FINISH as a supporting or an auxiliary verb. Leeson and Saeed (ibid.) distinguish between imperfective and perfective aspect where imperfective focuses on the internal structure of the event or process rather than the event as a whole, in particular its end points, which refers to perfective aspect.

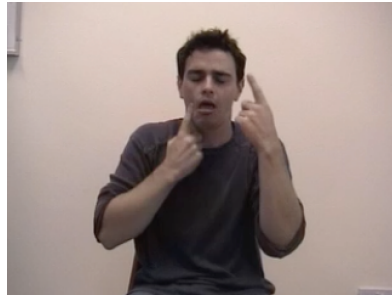


Figure 5.7 CRY++ '(The participants) bawled their eyes out', Signs of Ireland Corpus Sean (13) Personal Stories (Dublin), Leeson and Saeed (2012: 106, Example 5.20)

Aspect allows a signer to describe the timing of events. Aspect focuses on when something happened relative to another event, showing how long the event went on for, if it is complete or still in progress. In BSL, aspect may be shown in many ways, including verb inflection, separate lexical markers and constituent order (Sutton-Spence and Woll, 1999). ISL shows similarities in findings with regard to aspectual morphology in ASL, identified by Klima and Bellugi (1979). Similar to ASL, ISL utilises modifications in the movement parameter to articulate aspectual marking. Reduplication is particularly significant with regard to aspectual marking within ISL, where different verb types correspond to different dynamic situations.

Leeson and Saeed (2012) distinguish between imperfective and perfective aspect in ISL, where imperfective aspect focuses on the internal structure of the event or process rather than the external perfective viewpoint, which focuses on the event as a whole, in particular its end points. They identify an aspectually modified variant of the ISL punctual verb KNOCK where the repetitive aspect interacting with the verb marks a change on the interpretation. Typically, within ISL, the verb KNOCK would have two repetitions associated with it. In the case identified by Leeson and Saeed (ibid.) four repetitions signify an aspectually modified variant of the verb, which implies that the knocking occurred repeatedly and with urgency. The movement parameter involves a straight line from close to the signer to the locus associated with the object (in this case a door). They also identify the imperfective aspectual modification of durational verbs in ISL. Inflection of the durational verb CRY, is articulated by a repeated circular movement. The meaning communicated is of the extended duration of the event. Leeson (1996; 2001) identifies COMPLETION as a perfective marker that is used within ISL. COMPLETION can

precede the verb or come before a noun. Leeson (ibid.) agrees with Matthews (1996a) in that COMPLETION functions as a marker of resultatives, marking the successful result or outcome of a process. Similar aspectual forms are identified for ASL by Baker-Shenk and Cokely (1980) and Klima and Bellugi (1979). Leeson and Saeed (ibid.) also note that the aspectual information can be augmented by NMF showing that the subject was distressed and cried over a long time.

5.3.3 Manner

Leeson and Saeed (2012) identify ways in which the articulation of a sign representing a verb or an adjective may be modulated to provide further information regarding manner, intensity and also size. Figure 5.8 provides an example of the ISL motion verb WALK, which may be modulated away from the citation form to provide information about speed. In ISL a non-manual morpheme glossed as “mm” co-occurs with this manual sign. This provides adverbial information to show that the action occurred in the normal way (O’Baioill and Matthews, 2000).



Figure 5.8 WALK, Signs of Ireland Corpus Bernadette (02) Personal Stories (Dublin), Leeson and Saeed (2012: 122, Example 5.39a)

Leeson and Saeed also identify that within ISL, adjectives may be modulated to provide information regarding scale. It is also identified by Leeson and Saeed (2012) that temporary states expressed by verbs (for example: HUNGRY, TIRED) can also be modified, where movement of the verb is lengthened to convey the meaning of being “very” hungry or “very” tired. Figure 5.9 and Figure 5.10 identified by Leeson and Saeed (2012) provide various modulations of the adjective BIG in ISL.



Figure 5.9 BIG (citation), Signs of Ireland Corpus Fergus D. (06) Personal Stories (Dublin), Leeson and Saeed (2012: 123, Example 5.40a)



Figure 5.10 VERY-BIG-WINDOW, Signs of Ireland Corpus Lianne (14) Personal Stories (Dublin), Leeson and Saeed (2012: 123, Example 5.40c)

Manner in SL is used to specify how an action was carried out. SL uses NMF in the form of facial expressions to provide information in relation to manner. Sutton-Spence and Woll (1999) identify that we might describe all verbs as having an accompanying facial expression to provide information about the manner in which an action occurred (although often the manner may be neutral or unmarked).

In ISL the articulation of a sign representing a verb or an adjective may be modulated to provide further information regarding manner, intensity and also size. In ISL a non-manual morpheme glossed as “mm” co-occurs with this manual sign. This provides adverbial information to show that the action occurred “in the normal way” (O’ Baoill and Matthews, 2000). BSL also presents similar findings.

O’ Baoill and Matthews (2000) identify the use of change of pace or length of movement to mark adverbial or adjectival information. They also identify that while

in spoken English where the word *sick* may be used as a predicative adjective, within ISL the sign for *sick* functions in the same way as a verb, and in ISL can encode distinctions in terms of aspect for example being continuously sick.

5.3.4 Number in Person Agreement Verbs

Within the verbal domain ISL provides a variety of mechanisms to mark for number and plurality. Person agreement verbs show a distinction between single and plural arguments. Multiple or collective marking is represented by a smooth concave horizontal arc. Figure 5.11 from McDonnell (1996) illustrates this.



Figure 5.11 ISL non-specific plural: '(I) told all of them', McDonnell (1996: 171)

This plural may also be formed by a two handed sign in which each hand replicates the same form. An exhaustive plural where the action is allocated to each member of a group by a series of short convex arcs and a sideward movement. An example of an ISL sentence to illustrate an exhaustive plural taken from Leeson and Saeed (2012) would be: “I gave one to each of them”.

Finally, with regard to number in ISL, Leeson and Saeed (2012) identify repetitions that modify the verb with regard to attributive aspect. In this case the repetition modifies the verb, but the focus is not on the individuation of the plural argument. Leeson and Saeed describe how this form occurs with a distributive sense, for example: “They all met each other (distributive)”.

5.4 Current Approaches to Realisation of Agreement

Mathur and Rathmann (2012: 139) identify that a foundational issue within the literature concerning agreement is ‘whether it can be understood as the realisation of verb agreement, and if so, what are the relevant features in the realisation’.

Mathur and Rathmann (ibid.) provide a detailed discussion on these three approaches and identify the three general approaches to the realisation of verb agreement within SL literature are: the R-locus analysis (Lillo-Martin/Klima 1990), the indicating analysis (Liddell 2003) and the featural analysis (Padden 1983; Rathmann/Mathur 2006). These three approaches reflect differing theoretical stances on the part of the authors. Mathur and Rathmann (ibid.) provide an overview into the mechanics behind each approach is provided identifying which elements agree with which and in what features. Interaction within the signing space is also considered here.

5.4.1 R-Locus Analysis

The R-locus analysis (referential locus analysis) works by associating each noun phrase with an abstract referential index. The index is a variable within the linguistic system. It receives its value from the discourse. Its function is to keep the referent of the noun phrase distinct from other noun phrases. The index is realised in the form of a locus (the point in signing space that is associated with the referent of the noun phrase). This locus is referred to as a ‘referential locus’ or R-locus for short. There are theoretically an infinite number of R-loci in signing space. By separating the referential index, an abstract variable, from the R-locus, the analysis avoids the listability issue, which Mathur and Rathmann (2012) describe as the issue of listing each R-locus as a potential form in the lexicon. The following ASL example is taken from Mathur and Rathmann (2012), and it illustrates how the copying mechanism in R-locus analysis works.

Example 5.1

[s-u-e ix_a] [b-o-b ix_b] _aask_b [ASL]

R-locus for *Sue* R-locus for *Bob* ‘Sue asked Bob a question.’

(Mathur and Rathmann, 2012: 140)

Using this analysis, the noun phrase and verb share a referential index, which is described as an R-locus. It is understood that agreement occurs between the noun phrase and verb. Aronoff, Meir, and Sandler (2005) indicate one difference from agreement in spoken languages is that the R-loci that nouns are associated with are

not part of the nouns phonological representations and are not lexical properties of the nouns in any way. Rather, they are assigned to nouns anew in every discourse.

Mathur and Rathmann (2012) follow on their discussion by describing the work of Cormier, Wechsler, and Meier (1998). This research uses the theoretical framework of Head-driven Phrase Structure Grammar (HPSG), developed by Pollard and Sag (1994), to provide an explicit analysis of agreement as index-sharing. Within the HPSG lexical-based framework, the noun has a lexical entry, which specifies the value of its index. The index is defined with respect to the locus which can be one of three: the location directly in front of the signer's chest (*S*), the location associated with the addressee (*A*), or 'other'. This 'other' category is further divided into distinct locations in neutral space that are labeled as *i*, *j*, *k*, and so forth. Thus, they view the locus as a phi-feature in ASL, which is a value of the index. The listability issue is resolved if it is assumed that the index allows an infinite number of values. Cormier, Wechsler, and Meier (1998), describe a verb as having a lexical entry that is sorted according to single or double agreement. The entry includes specifications for phonology (PHON) and syntax and semantics (SYNSEM). The SYNSEM component contains the verb's argument structure (ARG-ST) and co-indexes the noun phrases with their respective semantic roles in CONTENT.

5.4.2 Indicating Analysis

Indicating analysis draws on mental space theory developed by Fauconnier (1984, 1997) to generate connections between linguistic elements and mental entities. Liddell (1990, 1995, 2000, 2003) challenges the R-locus analysis, arguing that verbs which display the phenomenon regarded as agreement in R-locus analysis are best understood as being directed to entities in mental spaces. Liddell does not consider the phenomenon to be an instance of verb agreement but refers to this type of verb as an 'indicating verb', because the verbs 'indicate' or point to referents just as one might gesture toward an item when saying "I would like to buy *this*" (Mathur and Rathmann, 2012: 142).

Liddell (2003) assumes that verbs are lexically marked for whether they indicate a single entity corresponding to the object (VERB^{/y}) or two entities corresponding to the subject and the object (VERB^{x/y}). He proposes a similar notation for other forms

involving plurality, as well as for spatial verbs (VERB^{/L}, where L stands for location). Constraints on the process of agreement, such as the restriction of the multiple form to the object, would have to be encoded in the lexicon.

5.4.3 Featural Analysis

Rathmann and Mathur (2002, 2008) proposed the featural analysis, which can be considered a hybrid of the R-locus and indicating analyses. It suggests that verbs agree with the subject and the object in the morphosyntactic features of person and number. The features for the category of person follow Meier (1990). First person is realised as a location on or near the chest, while non-first person is realised as a zero form.

Featural analysis concurs with the R-locus view on verb agreement. However, featural analysis represents agreement using features of the noun phrase instead of index-sharing or copying. The set of features is finite consisting just of person and number and each feature has a finite number of values. Featural analysis assumes only one person distinction under the heading of non-first person, which is referred to as a zero morpheme. The use of a zero morpheme is the solution to the listability issue.

5.5 Event Visibility Hypothesis

Wilbur (2008) proposed the Event Visibility Hypothesis, henceforth EVH, which states that in the predicate system, the semantics of the event structure is visible in the phonological form of the predicate sign. Predicate signs contain morphemes that reflect the event structure that they represent. Wilbur (ibid.) proposes that with the exception of classifier predicates (CLP) and spatial tracing movements, within the predicate domain in SL, the path movement of predicate signs indicates the temporal extent of an event (e), and that the path movement between sign repetitions reflects time between events (e). Wilbur (ibid.) also proposes that the phonological end-marking of the movement reflects the final state of telic events (e_n) and that movement that stops at points (p) in space also indicates individual argument semantic variables (x). Wilbur (2008: 218) proposes that:

“This mapping of semantic components and phonological forms represents a systematic recruitment of characteristics of the physical world for conceptual, hence morphological, semantic and syntactic purposes”.

Event structures are analysed as conceptual structures that correspond to morphemes in the lexicon. The EVH uses a model of event structure, which was developed from the sub-event analysis of Pustejovsky (1991, 1992, 1995, 2000), where events are composed of sub-events of two types: static (S) and dynamic process (P). The EVH deals with the temporal components events, and not with causation, agentivity, or linking. Wilbur (ibid.) proposes that there is a morphological mapping of sign formation and event structure in SL. In the predicate system, the semantics of the event structure is visible in the phonological form of the predicate sign.

Table 5.1, taken from Wilbur (2008) provides the proposed EVH morphemes and their description.

Table 5.1 Event Visibility Hypothesis proposed morphemes, Wilbur (2008: 220)

Morpheme Class	Function	Sub-event type	Phonological Form
EndState	Marker of telic events	State	Rapid deceleration to a stop
InitialState	Marker of initial state	State	Rapid acceleration from a stop
Extent	Duration of events	Process	Path, [tracing]
Path	Distance of spatial events	Process	Path, [tracing]
Extra	Adverbial Modifier		[Arc]
USET	Adverbial Temporal Modifier		Trilled Movement [TM]

Telic and atelic events are separated based on Wilbur (2003: 355):

“Transition predicates, which are telic, have a phonologically overt ‘EndState’ in their form, whereas states and processes, which are atelic, do not”.

Telic events are defined within the context of event structure as the property of events containing a natural conceptual/semantic endpoint. In contrast, atelic events do not contain such a point and have the potential to continue indefinitely, without any change in the internal structure. Telic events having a heterogeneous internal structure, as opposed to atelic events, which have a homogenous internal structure.

Rathmann (2005) provides an overview of Wilburs (2004) study where linguistic correlates for situation types that were found on the phonological level. Wilbur found that ASL signs denoting Transitions (following the terminology of Pustejovsky 1995, roughly the set of telic predicates, i.e. achievements and accomplishments) share the phonological property that there is a change in some *phonological parameter of the sign*. On the other hand, ASL signs for Processes (i.e. the set of atelic predicates, or activities and semelfactives) share a different phonological property. They all have path movement or “movement over a line”. They do not involve a change in *handshape* or *orientation*. The following table provides a summary of this overview.

Table 5.2 Summary of phonological feature change patterns in relation to situation types, based on Wilbur (2008: 220-222)

Phonological Feature	Achievement (telic)	Accomplishment (telic)	Activities (atelic)	Semelfactives (atelic)
<i>Movement</i>	May change	May change	Change	Change
<i>Orientation</i>	May change	May change	No change	No change
<i>Handshape</i>	May change	May change	No change	No change
<i>Location</i>	May change	May change	Change	Change

Wilbur draws on Brentari (1998) and the ASL prosodic model in the development of the EVH. The prosodic model Brentari (ibid.) provides a comprehensive theory of ASL phonology and the phonological organisation of signs. Feature geometry is applied in the hierarchical organisation of a sign's parameters based on phonological behavior and articulatory properties. A root lexeme branches into both Inherent Features (IF) and Prosodic Features (PF). IFs define those features that persist throughout the sign. IFs branch into the parameters of handshape and location/place of articulation (POA). The PF branch defines dynamic features that can change during the formation of a sign. PFs represent movement in ASL signs and require specification of at least two phonological timing slots (x-slots).

5.6 Analysing ISL Verbs and Associated Situation Types

ISL verbs for analysis were taken from the ISL corpus and also literature within the field (McDonnell 1996). The Table 5.3 provides examples of ISL glossed sentences taken from the SOI corpus. The ISL verb in each sentence is categorised according to the tripartite verb class, transitivity and situation type. Examples 5.2 through to Example 5.14 provide images of the ISL sentences below, which were also taken from the SOI corpus. As discussed in section 1.6.3, ISL verbs were initially categorised according to their tripartite verb category. Approximately thirty verbs were investigated using this criterion. These verbs were then categorised according to their ISL morphological verb classes (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) the next step in our investigation was to analyse the verbs further and determine each verbs Aktionsart classification or situation type (Vendler 1957). The relevant situation type was determined depending on the features displayed by the verb. Possible features of the verb include [$\pm$ static], [$\pm$ punctual], and [$\pm$ telic] as discussed previously in chapter three. Based on the features applied, the verbs were then classified as into distinct classes of states, activities, achievements and accomplishments, active accomplishments and semelfactives.

Table 5.3 Analysing ISL event types

Sentence	ISL Verb	ISL Verb Class	Transitivity	Aktionsart Class	Reference
REAL LIKE MY JOB 'I really love my job'	LIKE	plain	trans.	state	SOI Corpus Noleen (03) Personal Stories (Dublin)
OPEN HANDS PALM UP-CL DRIVE-ME- MAD 'They drive me mad'	DRIVE-ME- MAD	plain	intrans.	activity	SOI Corpus Noleen (03) Personal Stories (Dublin)
_____n NEVER LIKE LEAVE '(I would) never like to leave'	LIKE	plain	intrans	state	SOI Corpus Noleen (03) Personal Stories (Dublin)
SOME BOY THINK 'Some boys think'	THINK	plain	intrans	activity	SOI Corpus Noleen (03) Personal Stories (Dublin)
ARRIVE HOTEL '(I) arrived at the hotel'	ARRIVE	plain	intrans	achievement	SOI Corpus Mary (30) Personal Stories (Cork)
INDEX+c MAKE DINNER FOR SIGN NAME (Pat OShea) 'I made dinner for Pat O'Shea'	MAKE	plain	intrans	accomp.	SOI Corpus Alice (29) Personal Stories (Cork)
DAUGHTER RUN+sl TO HOTEL 'My daughter ran to the hotel'	RUN	locative agreement (spatial)	intrans	active accomp.	SOI Corpus Mary (30) Personal Stories (Cork)
c+ASK+f 'I ask you'	ASK	double agreement	trans	activity atelic/ durative	McDonnell (1996: 160, Example 5.58)

c+ACCUSE+f 'I blame you'	ACCUSE	double agreement	trans	activity	McDonnell (1996: 160, Example (5.62))
DISAPPEAR '(The dog) disappeared'	DISAPPEAR	plain	ntrans	semelfactive	SOI Corpus Rebecca (38) Personal Stories (Waterford)
BOY SLAP+face c 'The boy slapped me on the face'	SLAP	locative agreement (body anchored)	trans	achievement	McDonnell (1996: 179, Example 5.132)
c+CHOOSE+fl 'I chose (something)'	CHOOSE	backward agreement	trans	achievement telic punctual	SOI Corpus Kevin (17) Personal Stories (Dublin)
GUIDE TELL-ME 'The tour guide told me'	TELL-ME	single agreement	trans	activity atelic durative	SOI Corpus Mary (33) Personal Stories (Galway)
c+DISCUSS+f f+DISCUSS+c 'We discussed the issue'	DISCUSS	reciprocal agreement	trans	accomplishment Telic durative	SOI Corpus Annie (26) Personal Stories (Wexford)
DRIVE+f HOME 'I drove home'	DRIVE	locative agreement (spatial)	ntrans	active accomplishment	SOI Corpus Fergus D. (06) Personal Stories (Dublin)
c+GIVE+f '(I) gave (the dog) (food)'	GIVE	double agreement	ditrans.	achievement Punctual telic	SOI Corpus Rebecca (38) Personal Stories (Waterford)

Example 5.2

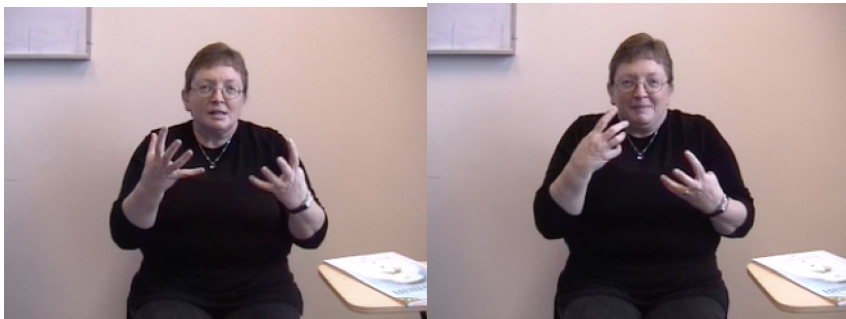


REAL LIKE MY JOB

‘I really love my job’

SOI Corpus Noeleen (03) Personal Stories (Dublin)

Example 5.3

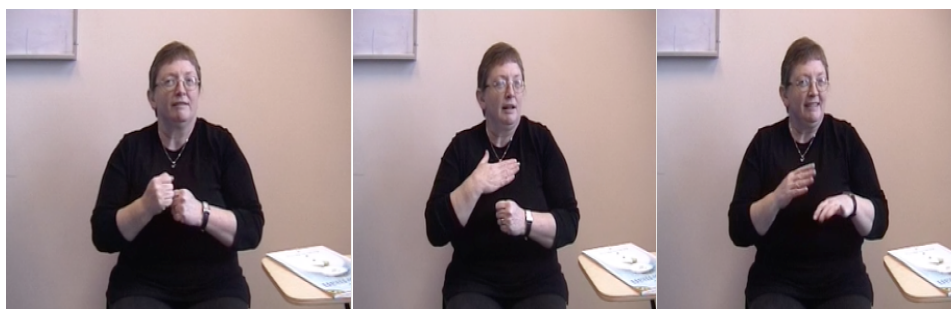


OPEN HANDS PALM UP-CL DRIVE-ME-MAD

‘They drive me mad’

SOI Corpus Noeleen (03) Personal Stories (Dublin)

Example 5.4

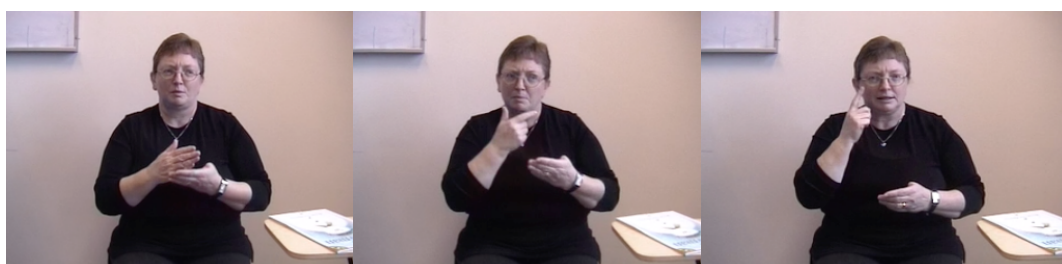


_____n
NEVER LIKE LEAVE

‘(I would) never like to leave’

SOI Corpus Noeleen (03) Personal Stories (Dublin)

Example 5.5

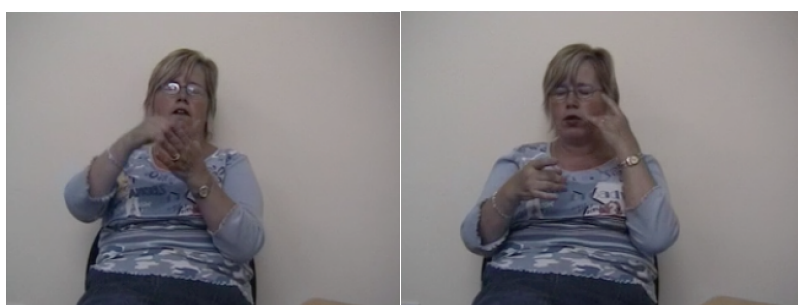


SOME BOY THINK

‘Some boys think’

SOI Corpus Noeleen (03) Personal Stories (Dublin)

Example 5.6

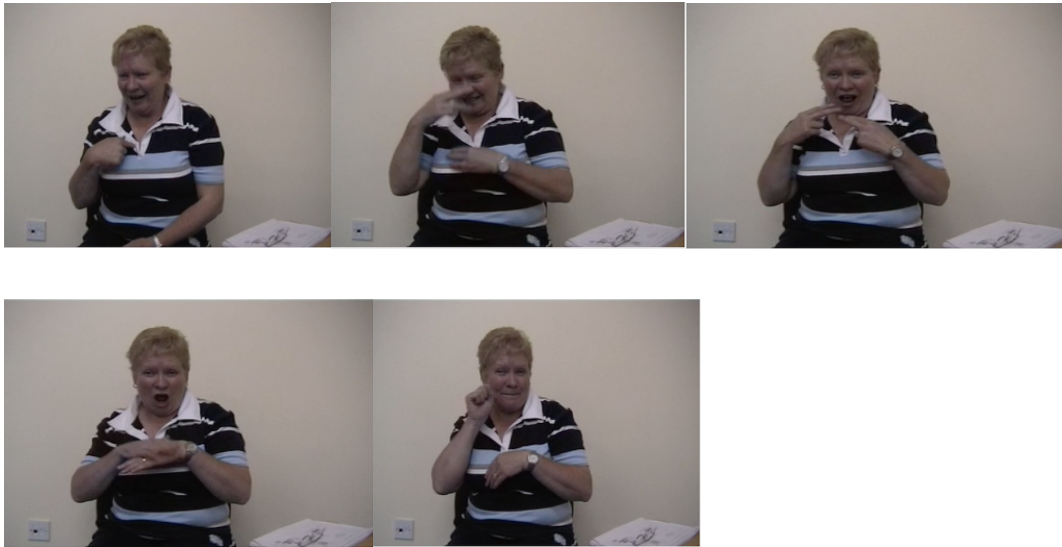


ARRIVE HOTEL

‘(I) arrived at the hotel’

SOI Corpus Mary (30) Personal Stories (Cork)

Example 5.7



FOR SIGN NAME (Pat O'Shea)

INDEX+c MAKE DINNER FOR SIGN NAME (Pat O'Shea)

'I made dinner for Pat O'Shea'

SOI Corpus Alice (29) Personal Stories (Cork)

Example 5.8



DAUGHTER RUN TO HOTEL

'My daughter ran to the hotel'

SOI Corpus Mary (30) Personal Stories (Cork)

Example 5.9



DISAPPEAR

‘(the dog) disappeared’

SOI Corpus Rebecca (38) Personal Stories (Waterford)

Example 5.10



c+CHOOSE+fl

‘I chose (something)’

SOI Corpus Kevin (17) Personal Stories (Dublin)

Example 5.11



GUIDE TELL-ME

‘The tour guide told me’

SOI Corpus Mary (33) Personal Stories (Galway)

Example 5.12



C+DISCUSS+f

f+DISCUSS+c

‘We discussed the issue’

SOI Corpus Annie (26) Personal Stories (Wexford)

Example 5.13



DRIVE+f HOME

‘I drove home’

SOI Corpus Fergus D. (06) Personal Stories (Dublin)

Example 5.14



c+GIVE+f

‘(I) gave (the dog) (food)’

SOI Corpus Rebecca (38) Personal Stories (Waterford)

On investigation of ISL verbs and the associated Aktionsart classes it was found that ISL shows linguistic correlates for five situation types: states, activities, achievements, accomplishments and semelfactives. From the investigation carried out here there are no apparent patterns or correlations between the traditional tripartite verb classes in ISL and the situation types associated with ISL verbs or indeed the transitivity of the verb. However, drawing on Wilbur (2008) and

correlations found in relation to event types and SL verbs we provide the following proposal in relation to the lexical representation for Aktionsart classes for ISL.

Wilbur (2008) used Pustejovsky's terminology for event structure and argues that transition events, which are telic, have a phonologically overt 'EndState' in their form, whereas States and Processes, which are atelic, do not. Wilbur (ibid.) proposes that states, activities and semelfactives (homogenous atelic events) all have path movement or "movement over a line". They do not involve a change in handshape or orientation. Building on this theory and with reference to Articulatory Structure Level and the computational phonological parameters defined in Murtagh (2015a), we propose that in relation to lexical entries for atelic situation types: states, activities and semelfactives, the initial specification for handshape <HS> and orientation <ORI> will remain for the duration of the event. All other features including wrist <WRIST>, forearm <F_ARM>, upper arm <U_ARM> and location <LOC> may change from the initial specification or point in 3D space across the duration of the event to a different specification or point in 3D space.

Based on Wilbur (2008), in the case of *handshape* and *orientation* it is a certainty that the specification for initial state will hold for the duration of the event. Therefore, <HS> and <ORI> will be initialised and the final positioning specification for these two parameters will be set to the same values as the initial parameter settings. Figure 5.12 illustrates the computational phonological parameters that will be available at the beginning of an ISL articulation. The parameters for ISL NMF parameters are initially empty therefore we use the notation <...>. Figure 5.12 provides an illustration of the choice of parameter that can be passed in as a parameter in the realisation of the event.

```

<HS><LOC>[(<body_initial>(head), (arm), (hand, (trunk)) || (<spatial>(upper),
(mid), (lower))..... (<body_end>(head), (arm), (hand), (trunk)) ||
(<spatial>(upper), (mid), (lower))]] timeline[eventDuration(f1IShape( xi,yi,zi),
(f2IShape( xi,yi,zi ), f3IShape( xi,yi,zi ), f4IShape( xi,yi,zi ), TShapeI(xi,yi,zi).....
(F1EShape (xn, yn, zn), (f2EShape (xn, yn, zn), f3EShape (xn, yn, zn), f4EShape
(xn, yn, zn), TShapeE (xn, yn, zn))]
<PO> timeline [eventDuration (p_initial (xi, yi, zi)..... p_end (xi,yi,zi))]
<AM> timeline [eventDuration (w_initial ( xi,yi,zi).....w_end(xi,yi,zi))]
<FA> timeline [eventDuration (f_initial ( xi,yi,zi).....f_end(xi,yi,zi))]
<UA> timeline [eventDuration (u_initial ( xi,yi,zi).....u_end(xi,yi,zi))]
<HEAD> timeline [eventDuration (<.....>)]
<EB> timeline [eventDuration (<.....>)]
<EL> timeline [eventDuration (<.....>)]
<EG> timeline [eventDuration (<.....>)]
<CHK> timeline [eventDuration (<.....>)]
<MTH> timeline [eventDuration (<.....>)]
<TNG> timeline [eventDuration (<.....>)]
<SHL> timeline [eventDuration (<.....>)]

```

Figure 5.12 Computational phonological parameters for ISL realisation of atelic events

NMF computational phonological parameters may be used simultaneously along with the MF parameters. Table 5.4 provides ISL NMF phonological parameters and their associated phonemes.

Table 5.4 ISL NMF phonological parameters with associated phonemes

ISL NMF Phonological Parameter	ISL NMF Phoneme
Head	nod, shake, tilt_left, tilt_right, turn_left, turn_right, chin_chest, chin_L_shoulder, chin_R_shoulder
EyeBrow (left and right simultaneous)	neutral, frown, arch
EyeLids (left and right simultaneous)	neutral, wide, squint, blink, closed
EyeGaze(left and right simultaneous)	neutral, left, right, up, down, left_up, left_down, right_up, right_down, locus
Cheek (left and right simultaneous)	suck_in, blow
Mouth	neutral, open_wide, closed_tight, smile_teeth, smile_teeth_wide, smile_closed, round_open, round_closed
²⁴ Tongue	in, out_pointed_1, out_pointed_2, out_pointed_3, out_round_1, out_round_2, out_round_3
R_Shoulder	neutral, up, down
L_Shoulder	neutral, up, down

With reference to Wilbur (2012) and with regard to the situation types of *achievements* and *accomplishments*, the initial specification for handshape <HS> and orientation <ORI> does not remain for the duration of the event. Similar to all of the other MF including wrist <WRIST>, forearm <F_ARM>, upper arm <U_ARM> and location <LOC>.

It is proposed that a template similar to Figure 5.12 is available in terms of the lexical representation of ISL verbs. This template will represent the Articulatory Structure Level parameters (Murtagh, 2015a) and will be initialised once an ISL articulation begins. The template chosen will be based on the Aktionsart class associated with the ISL verb in the sentence. States, Activities and Semelfactives (atelic events) will have access to a template where the <HS> and <ORI> parameters have an initial and final specification that is the same for the duration of the articulation based on the EVH. Achievements and Accomplishments will have access to a template where the <HS> and <ORI> parameters have an initial and final specification that is different for the duration of the articulation.

²⁴ With regard to the Tongue phonological parameter, the values 1, 2 and 3 in relation to protrusion define the percentage of the tongue which will protrude past the lips. 1 represents 10%, 2 represents 60 % and 3 represents 100% protrusion.

initial and final specification which will vary depending on the event and the sentence being articulated. It is important to note that parameters relating to the timeline (overall time taken to communicate the entire ISL lexeme, utterance or sentence) and also the duration taken to realise each computational phonological parameter must be recorded. Also, in relation to the handshape, the location in space (spatial or body-anchored) in which the handshape is realised must also be initialised and tracked for the duration of the event and also with regard to the overall timeline or duration of the articulation.

5.7 Defining RRG Logical Structures for ISL Plain Verbs

In terms of defining the RRG Logical Structure for ISL verbs we begin by looking to our analysis of ISL verbs. Both ISL plain verbs and agreement verbs show linguistic correlates to all five situation types for ISL. Mapping the new Articulatory Structure Level definitions from chapter 4 to RRG logical structures based on event/situation type we provide a proposal for RRG logical structures for ISL plain verbs.

In Example 5.14 and Example 5.15 we illustrate that we have reduced the parameters displayed for ease of illustration by using a <MF> parameter, which represents MF computational phonological parameters and <NMF>, which represents NMF computational phonological parameters based on Articulatory Structure Level. The parameter for timeline <Tline>, which is essential for representing the overall timeline for all <MF> and <NMF> parameters for the entire ISL articulation is included at this level. The parameter for <LOC> must also be considered here based on the Articulatory Structure Level spatial signing allocation map in Table 4.12 and also on the body anchored location categories in Table 4.2. In Example 5.4 above we have an example from the SOI corpus which includes a gloss that is clustered with both MFs and NMFs. In this situation, the Sign_A framework would pass information to both MFs and NMFs.

Example 5.16 provides an illustration of the subcategories that sit behind the <MF> and <NMF> parameters in the logical structures that follow in Example 5.16. The information relating to the MF and NMF parameters are described in more granular detail in Table 4.9 and Table 4.3 respectively.

Example 5.14

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

Example 5.15

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

The following Example 5.16 provides our proposed RRG logical structures for ISL plain verbs based on their associated situation types. Plain verbs are typically not marked for person or location (McDonnell 1996: 116). Example 5.16 a) provides the RRG logical structure for ISL plain verb LOVE, which has a situation type of *state*. The participant is referring to the fact that she loves her job, with job being introduced and established earlier in the discourse. In Example 5.16b) we provide the logical structure for the ISL verb THINK, which has an *activity* situation type. The participant establishes earlier in the conversation that she is referring to BOY (plural) or boys. The participant then uses the sign for BOY to refer to BOY (plural) or boys. Example 5.16 c) provides an ISL plain verb with a situation type of *semelfactive*. This example provides a plain verb DISAPPEAR with the participant referring to her dog and the fact that he had disappeared. The dog in this case has been established earlier in the story. In Example 5.16 d) the ISL verb ARRIVE has a situation type of *achievement*. In this example the participant establishes that she is driving to the hotel previous to this sentence where she arrives at the hotel. Reference to the participant ‘PRON1’ or c-locus had been established previously. Example 5.16 e) provides an RRG logical structure for the ISL verb MAKE, which has a situation type of *accomplishment*. In this example the participant tells the story of making dinner for Pat O’Shea.

Example 5.16

a) State

REAL LIKE MY JOB

‘I really love my job’

LIKE’ <TLine><MF><NMF> (1sg, JOB)

Based on Example 5.2, SOI Corpus Noeleen (03) Personal Stories (Dublin)

b) Activity

SOME BOY THINK

‘Some boys think’

do'(BOY.pl, [**THINK'**<TLine><MF><NMF> (BOY.pl)])

Based on Example 5.5, SOI Corpus Noeleen (03) Personal Stories (Dublin)

c) Semelfactive

DISAPPEAR

‘(The dog) disappeared’

SEML **do'**(DOG, [**DISAPPEAR'**<TLine><MF><NMF> (DOG)])

Based on Example 5.9, SOI Corpus Rebecca (38) Personal Stories (Waterford)

d) Achievement

ARRIVE HOTEL

‘(I) arrived at the hotel’

INGR **ARRIVE'**<TLine><MF><NMF> (HOTEL)

Based on Example 5.6, SOI Corpus Mary (30) Personal Stories (Cork)

e) Accomplishment

INDEX+c MAKE DINNER FOR SIGN-NAME (Pat OShea)

‘I made dinner for Pat O’Shea’

BECOME **COOK'**<TLine><MF><NMF> (1sg, DINNER) + be_at (DINNER, SIGNNAME)

Based on Example 5.7, SOI Corpus Alice (29) Personal Stories (Cork)

5.8 Defining RRG Logical Structures for ISL Agreement and Spatial Verbs

Interpreting the linguistic phenomena associated with ISL agreement and introducing this into the logical structures of RRG is anything but a simple process. Brentari (1989) produced a syntactic account of agreement verbs and observed that the within SL communication and with reference to ASL verbs, that the orientation of the palm of the hand is representative of the marking of spatial agreement. Meir (1998ab, 2002) produced a thematic analysis of verb agreement that includes a semantic and syntactic account. In summary, Meir's proposal allowed that in terms of the semantics of the verb, the path movement (as opposed to local movement) marked the semantic source/goal relationship, while the facing of the hand(s) marked the syntactic object argument. Meir observed that while orientation was the term used to represent the direction the palm was facing, *facing* was a more appropriate term to use as this accounted for orientation of the palm of the hand, finger tips or side of the hand, deeming all of these locations as capable of marking the syntactic locus depending on the verb being utilised. The various different theoretical approaches *r-locus analysis*, *indicating analysis* and *featural analysis* have been described in section 5.3.

Taking this into account we look again to RRG logical structures for ISL agreement and spatial verbs and propose that accounting for the event types associated with ISL verbs is not sufficient in representing the semantics of these verbs. These highly complex structures encode information in terms of their visual gestural modality and therefore it proves very challenging to account for certain linguistic phenomena using only association to Aktionsart classes as a representation mechanism.

There is no doubt that spoken language linguistics has influenced our approach in the development of SL linguistics, however in the case of developing logical structures for SL it isn't sufficient to use structures that are satisfactory in the representation of spoken language due the difference in modality. ISL is a visual gestural language and therefore logical structure entries of ISL verbs must allow for this. While Aktionsart classes may be used to capture a certain amount of information pertinent to SL verbs in terms of the four levels of lexical representation (argument, event, qualia and inheritance) within the GL framework (Pustejovsky, 1991), the Articulatory Structure Level has not been accounted for in

terms of RRG and so a proposal to allow for this within RRG logical structures for ISL follows.

Following Meir (1998b, 2002) with regard to Israeli SL in terms of agreement and spatial verbs, path movement within 3D space and the facing of the hands are used to denote motion and transfer respectively. The lexical structure for these type of verbs denotes transfer from source to goal. Person agreement verbs are morphologically linked to participants. They agree with actor and undergoer, which can be mapped to grammatical roles of subject and object. Locative agreement verbs are morphologically linked to locations and their arguments are derived from source/goal and theme (moving item) or location. The goal and theme can be mapped to grammatical roles of object and subject respectively. With regard to both person and locative agreement verbs in Israeli SL, the semantic roles are inflected by direction of path movement while the syntactic role is represented by the facing of the verb. Spatial verbs represent locations in space and denote motion and location in space. Spatial verbs encode the locations of locative arguments, (the source and the goal) based on the direction of movement of the hands. The shape of the path movement the hands are tracing is said to often depict the shape of the path that an object traverses in space.

Bearing all of this information in mind we must look to RRG logical structures for ISL agreement verbs and refer in particular to the computational phonological parameters for MFs and NMFs together with the temporal parameters defined within the Sign_A framework Articulatory Structure Level .

The movement parameter as described earlier can capture information on *interaction, contact, direction* and *manner*. At this point in our framework development, we are interested specifically in the semantics of this parameter. In terms of the semantic roles agreement verbs are inflected by the *direction* of the *path movement*. Agreement verbs mark subject and object by the *location in space* or *on the body* at the start and end of the verb articulation respectively, reversing this for backward agreement verbs. Also in terms of spatial verbs and in terms of encoding the locations of locative arguments, the semantic role of source and goal are marked based on the *direction* of movement of the hands. With spatial verbs, the shape of the path traversed by an entity is depicted by the *path movement* of the

hands. The following example provides our proposed RRG logical structures for ISL agreement verbs based on their associated situation types.

Example 5.17

a) 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> (^a1sg , ^b2sg)])

<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

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

<ORI> palm down, fingertips forward

Example 5.17 a) provides an ISL double person 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 or L1 on the Sign_A framework signing space allocation map in Figure 4.2. The movement is towards the ^b locus (in this case f or forward locus representing YOU), which has a location in at L2_mid on the Sign_A framework signing space allocation map. Movement occurs from ^alocus to ^blocus.

b) Semelfactive (spatial location)

KNOCK++++

‘I was banging down the door’

SOI Corpus Catherine (31) Personal Stories (Cork)

SEML ^{a elided} **KNOCK** ^{b elided} <TLine><MF><NMF> ((^{a elided} 1sg, ^{b elided} door)

<HS> one hand [4]

<LOC> (^{a elided} referring to signer not overtly realised in the syntax) (^{b elided} the door located at L2_upper on the Sign_A allocation map is also salient in discourse common ground, and elided in the syntax) // marks for source and goal or subject and object

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

<ORI> palm moving upwards and then downwards



KNOCK++++

‘I was banging down the door’

SOI Corpus Catherine (31) Personal Stories (Cork)

Example 5.17 b) provides an ISL spatial locative verb KNOCK++++ displaying iterative aspect, knocking repeatedly, and with urgency. The door that the participant is knocking on was established previously in the discourse and therefore it is salient. The participant in this case provides an aspectually modified variant of the verb KNOCK++++ representing four repetitions (typically there are two). This aspectual variation will be marked under aspect within our framework. The event duration parameter will allow us to increase the speed of knocking and also for the repeated knocking. NMFs will also be catered for based on instantiating the appropriate parameters defined previously in Table 5.4.

c) Achievement (body anchored location)

BOY SLAP+face c

‘The boy slapped me on the face’

McDonnell (1996: 179, Example 5.132)

on(^cface,[^aSLAP'^b<TLine><MF><NMF> (^aBOY, ^b1sg)])

<HS> one hand [1]

<LOC> (^alocus pronominal reference/source or subject (the boy)) (^blocus person being slapped.) (^clocus is the body anchored location or goal (the face))

<MOV> from ^alocus to ^clocus //shows direction

<ORI> palm towards signer's face

Example 5.17 c) Provides the proposed logical structure for the ISL body anchored locative agreement verb SLAP. Similar to the spoken language RRG logical structure for English, the *slap* occurs *on* the location of *the face*. The PP expresses the location of the event of slapping and therefore, *on* is identified as the highest predicate in the logical structure and it takes *the face* and the logical structure for *slap* as its two arguments. (Slobin and Hoiting (1994) provides a reference to movement in spoken and signed languages, where space is used to represent space and motion is used to represent motion.) The ^clocus is a body anchored location (the face) and it is associated with the ^blocus (the signer in this case) as the slap occurs on the signer's face. We provide a list of ISL NMF body anchored locations in Table 4.2. The NMF location allocation will be used to situate the slap on either the right or the left cheek of the signer in this example.

d) Activity (reciprocal agreement)

c+DISCUSS+f

f+DISCUSS+c

‘We discussed the issue’

SOI Corpus Annie (26) Personal Stories (Wexford)

do'(1sg and 2sg , [^a **DISCUSS'**^b <TLine><MF> <LOC> <NMF>

(^a1sg and 2sg , ^b2sg)])

<HS> two hands same shape

<LOC> (^alocus: refers to the signer L1) (^blocus: refers to L2_mid locus where one or more participants have been established.

<MOV> plural form 'we' represented by movement from L2_mid toward signer L1 using two hands alternately iterating around //shows direction and iterative nature

<ORI> palm upwards and tilted towards signer's face



SOI Corpus Annie (26) Personal Stories (Wexford)

Example 5.17 d) provides an ISL reciprocal agreement verb DISCUSS, which has a situation type of accomplishment. The signer uses both hands (c referring to canonical locus) which has a location in front of the signer's chest or L1 on the Sign_A framework signing space allocation map in Figure 4.12 and f locus, which has a location of f forward in front of the signer chest or at L2_mid on the Sign_A framework signing space allocation map. ^{ab}locus represents 'c' (canonical locus) and 'f'(forward locus) respectively. "the issue" is situated in this case within the ^clocus.

Movement occurs from ^a locus to ^b locus alternating the hands in a circular motion representing 'we' and also representing the iterative nature of the verb. The verb DISCUSS is also mouthed using NMFs.

This proposal for RRG logical structures relates to the R-Locus (referential locus) theory in that the noun phrase and verb share a referential index or location in 3D space. Agreement occurs between the noun phrase and the verb. Further information

on the noun, noun phrases and lexical entries and the semantics of nouns can be found in chapter 7.

In the case of verbs and RRG logical structures, it proposed that ISL verbs are categorised according to Aktionsart classes and also by plain or agreement categories. Agreement verbs inflect for person agreement and locative agreement. The logical structure entries for ISL verbs includes specifications for the computational phonological parameters which are defined at the Articulatory Structure Level within our Sign_A framework. These parameters are represented in the extended GL theory (Pustejovsky 1991), where we propose a fifth level of lexical representation be added to account for the essential (computational) phonological parameters of an object as defined by the lexical item. It should be noted that the theory of EVH holds in relation to initial and end states for <HS> and <ORI> parameters, where there was no change in either of these for the activity agreement verb ACCUSE in Example 5.17 a).

5.9 Summary

In this chapter we addressed a portion of RQ3: How might lexical entries look for ISL classifiers, ISL verbs and ISL nouns within the RRG lexicon? We do this by defining what the lexical entries for ISL verbs might look like within the RRG lexicon. We further investigated the literature in relation to SL verbs, specifically ISL verbs. We analysed various verb types from the SOI corpus and subsequently categorised these according to the SL verbs traditional tripartite verb class, its transitivity and its situation type. On investigation of ISL verbs and the associated Aktionsart classes we identified that ISL shows linguistic correlates for five situation types: states, activities, achievements, accomplishments and semelfactives. On analysis of ISL verbs in relation to Wilbur (2008) and the EVH we identify ISL verb behavior is in agreement with Wilbur's hypothesis. Finally we provide a template for the computational phonological parameters necessary for ISL realisation. Based on these parameters and referring specifically to Articulatory Structure Level in terms of lexical meaning for ISL and the essential (computational) phonological parameters of an object as defined by the lexical item, we provide the RRG logical structure for the ISL plain verbs and ISL agreement and spatial verbs based on their respective event/situation type.

6. Classifiers

6.1 Introduction

In this chapter we continue to address RQ 3. We provide a definition for the structure of lexical entries for ISL classifiers also known as depicting verbs (Liddell 2003). In order to provide background on our analysis of ISL classifiers we first outline the morphological and grammatical information that is encoded by these units of ISL. We provide an account of classifiers in both spoken language and in SL. We provide an account of ISL classifier handshapes from the literature. We examine ISL classifiers in terms of their behavior, based on the category of classifier they are associated with. We look to the SOI corpus to analyse classifier predicates in ISL. Finally we provide an account of how ISL classifiers may be represented within the lexicon in linguistically motivated computational terms. We utilise our newly defined Articulatory Structure Level to cater for ISL classifiers in terms of lexical meaning for ISL and the essential (computational) phonological parameters of an object as defined by the lexical item.

It should be noted that while classifiers form a well-researched topic in SL linguistics and have been observed in the majority of SLs studied to date, there is still much debate within the research regarding a variety of matters (Zwitserslood 2012). With regard to this research work and terminology and naming the broader term *complex predicates* lends itself a more appropriate term of reference allowing for the difficulties presented by these highly complex linguistic units. However, for simplicity within this document I will use the more traditional term classifier, referring to those SL verbs that use ‘topographic space, and rather than inflecting for person or number they give information about the path, trajectory, speed and location’ (Morgan and Woll, 2007).

6.2 Spoken Language Classifiers

Within the realm of spoken language, classifiers are predominantly found in South East Asian Languages (Thai, Chinese), in African Languages (Somali) and in American Indian Languages (Navajo) (O’Baill and Matthews, 2000). Various

morphemes are used to classify an object as belonging to a specific lexical set, depending on how the object is perceived.

Figure 6.1 taken from Gao and Malt (2009), provides an example of classifier usage in Mandarin Chinese, where the first character on the top left corner indicates a classifier for a tree. The second line from the top and the subsequent lines show different types of tree using the first character to denote the type of tree and the second character to denote the tree classifier.

树 (tree), 草 (grass), 玉米 (corn), 白菜 (cabbage),
松树 (pine tree), 柳树 (willow tree),
果树 (fruit tree), 梨树 (pear tree),
苹果树 (apple tree), 古树 (ancient tree),
高树 (tall tree), 矮树 (short tree)

Figure 6.1 Classifier usage in Chinese, Gao and Malt (2009: 1138)

Zwitserlood (2012) provides an overview of recent research in spoken language classifiers. Initial research in this area, which began in the 1970s, posited that there were various classifier systems being employed by the world's languages. As mentioned previously in section 2.5.7.1, it seems that the early study of SL classifiers was heavily influenced by this literature on spoken language classifiers. Allan (1977) divided spoken language classifiers into four distinct types, one of which was defined as a "predicate classifier language" (e.g. Navajo). Classifiers in SL were likened to this type, however further research has shown that early work on the comparison of classifiers in ASL and this predicate classifier language was based on a misinterpretation of the classificatory system of Navajo (Engberg-Pedersen 1993; Schembri 2001; Zwitserlood 1996, 2003). Aikhenvald (2000) and Grinevald (2000) identify Navajo as a language that contains *classificatory verbs* rather than *classifier verbs*. The difference lies in the fact that in classificatory verbs, the verb stem itself is responsible for classification of the referent involved in the event and no separate classifying morpheme can be discerned whereas in classifier verbs a separate verb stem and classifier can be distinguished.

Zwitserlood (2012) reports that recent research within spoken language literature on classifiers, particularly spoken language *verbal classifiers*, presents similarities to classifiers within SL in terms of two main findings, namely, the lexical function of *word/sign formation* and also the grammatical function of *reference tracking*. One difference that has been revealed is that within the SL system of communication verbal classifiers are the only classifier to exist, whereas there are at least four different classifier systems within spoken language.

6.3 Sign Language Classifiers

Zwitserlood (2012) provides an overview of the current status of SL classifiers in terms of the literature and concludes that although much work has been done in terms of classifiers and classifier constructions and many different claims and generalisations have been made resulting in various theories, there is still much controversy in this area of sign linguistics. Due to differing opinions among researchers, classifiers are still subject to much debate with respect to a variety of issues including their structure, naming and also the different the categories of classifiers, which have been identified. It seems that across the greater sign linguistics research community, these issues currently remain unresolved and further research is necessary in order to provide a solution to these outstanding problems. Section 2.5.6 provides an account of classifiers in relation to ISL.

6.3.1 Classifier Terminology Issues

Schembri (2003) makes reference to the various terms used within sign linguistics literature to refer to these linguistically complex constructions. Across Australia they are broadly known as *classifier signs* or simply *classifiers* (Bernal, 1997; Branson et al., 1995). Other researchers refer to *classifier verbs* or *verbs of motion and location* (Supalla, 1986, 1999), *classifier predicates* (Corazza, 1990; Schick, 1997, 1990; Smith 1990; Valli and Lucas 1995; Leeson and Saeed 2012), *spatial-locative predicates* (Lidell and Johnson, 1987), *polymorphemic predicates* (Collins-Ahlgren, 1990; Wallin 1990), *polysynthetic signs* (Takkinen, 1996; Wallin 1996, 1998), *productive signs* (Brennan, 1992; Wallin 1998), *polycomponential signs* (Slobin et al., 2001), and *polymorphemic verbs* (Engberg-Pedersen, 1993). Liddell (2003) refers to this category of sign as a depicting verb. Schembri refers to this

category of signs as polycomponential verbs (PVs) and defines this type of verb as (Schembri 2003). In more contemporary literature Cormier et al. (2013a: 370) uses the term depicting construction (DC) to refer to ‘a structure where the hand represents the location and/or motion of an entity’. Cormier (ibid.) reports that these type of structures are also referred to as classifier constructions, depicting signs, depicting verbs, or verbs of location and motion.

6.3.2 Sign Language Classifier Categories

To date there is still very little agreement among researchers as to the various category of classifier that exists among the SLs of the world. Supalla (1982, 1986) categorises ASL classifiers into five categories. These are listed in the Table 6.1 taken from Zwitserlood (2012).

Table 6.1 Five categories of classifier predicates in ASL, based on Supalla (1982: 33-63)

Category	Description
Semantic Classifiers	Represent nouns by some semantic characteristic of their referents (e.g., belonging to the class of humans, animals, or vehicles)
Size and Shape Specifiers (SASSes)	Denote nouns according to the visual-geometric features of their referents. SASSes come in two subtypes: - static SASSes, which consist of a handshape (or combination of two hands) that indicates the size/shape of an entity - tracing SASSes, which have a movement of the hand(s) that outlines an entity’s size/shape, and in which the shape of the manual articulator denotes the dimensionality of that entity
Instrumental Classifiers	Instrumental hand classifiers, in which the hand represents a hand that holds and/or manipulates another entity
Bodypart Classifiers	Parts of the body represent themselves (e.g., hands, eyes) or limbs (e.g., hands, feet)
Body Classifier	The body of the signer represents an animate entity.

Recent research on Body classifiers define these as a special type of classifier as they are not represented phonologically by handshape, but by the signer's own body and also they cannot be combined with verbs of motion or location. Some research identifies these no longer as classifiers but as a means for referential shift (Engberg-Pedersen 1995; Morgan and Woll 2003). Dudis (2004) uses real space blends and a cognitive perspective in his description of the process applied by ASL signer's in simultaneous constructions. Dudis (ibid.) describes a subdivision of the body to represent a number of different actors at the same time. Schembri (2003) describes how the lack of agreement among researchers on the various categories of classifiers and also on the classification of what exists within each category has obstructed any satisfactory cross-linguistic comparison of the forms. Table 6.2, taken from Schembri (2003), provides a list of researchers and the approach they have taken in classifying classifiers in signed languages.

Table 6.2 Classification of classifiers in signed language, Schembri (2003: 10)

Research	Entity/Handshape Units	Handle Handshape Units	SASS Handshape Units
Supalla	Static SASSes, semantic, bodypart, some instrument classifiers	Some instrument classifiers	Non-static SASSes
McDonald	Some x-type of object classifiers	Handle x-type of object	Some x-type of object
Shepard-Kegl	Shape/object classifiers	Handling classifiers	-
Johnston	Substitutors/proforms	Some manipulators	Some manipulators
Corazza	Surface, some grab, perimeter and some quantity (?) classifiers	Some grab classifiers	Descriptive, some perimeter and some quantity (?) classifiers
Brennan	Semantic classifiers, some SASSes	Handling, instrumental and touch classifiers	Tracing classifiers and some SASSes
Schick	Class classifiers, some SASSes	Handle classifiers	Some SASSes
Engberg-Pedersen	Whole entity stems, some limb stems	Handle stems and some limb stems	Extension stems
Liddell & Johnson	Whole entity, surface, on-surface classifiers and some extent (?) classifiers	Instrumental classifiers	Depth and width, perimeter-shape and some extent (?) classifiers
Zwitserslood	Object	Handle	-

Zwitserslood (2012) goes on to posit that tracing SASSes also belong outside the domain of classifiers. The following list taken from Zwitserslood (2012) defends this decision in terms of tracing SASSes.

- (1) They are not expressed by a mere hand configuration, they also need the tracing movement to indicate the shape of the referent.
- (2) They cannot be combined with verbs of motion.
- (3) They denote specific shape information (in fact all kinds of shapes can be outlined, from square to star-shaped to Italy- shaped).

(4) They can be used in a variety of syntactic contexts: they appear as nouns, adjectives, and (ad)verbs, and do not seem to be used anaphorically (as will be exemplified in the next section).

According to Zwitserlood, recent research in relation to SL classifiers distinguishes just two major categories of classifier, which are illustrated in Table 6.3.

Table 6.3 Two generally accepted categories of classifier predicates, based on Zwitserlood (2012: 161)

Category	Description
Whole Entity Classifiers	In these verbs the classifier represents the referent directly. Occur in verbs that express a motion of a referent, or its location or existence in space.
Handling Classifiers	Occur with verbs that show the manipulated motion or the holding of a referent.

The Whole Entity Classifier category seems to encompass Supalla's Semantic Classifiers, Static SASSes, some Body-Part Classifiers, and Tool Classifiers. In the category of Handling Classifiers we find classifiers that represent entities that are being held and/or moved; often (but not exclusively) by a human agent. This category contains classifiers that were previously categorised as Instrumental classifiers and some Body-part classifiers. Zwitserlood (2012) goes on to describe how research has identified a close connection between the category of classifier and the transitivity of the verb: Whole Entity Classifiers occur with intransitive verbs, whereas Handling Classifiers are used with transitive verbs.

6.3.3 Classifiers and Verb Morphology

Zwitserlood (2012: 167) reports that there is a close connection between 'the category of classifier and the transitivity of the verb: Whole Entity classifiers occur with intransitive verbs, whereas Handling classifiers are used with transitive verbs'.

Supalla (1982), Glück and Pfau (1998, 1999), Zwitserlood (2003), and Benedicto and Brentari (2004), consider the classifier in these verbs as a functional element: an agreement marker, which functions in addition to agreement by use of loci in sign. Benedicto and Brentari (2004) furthermore claim that the classifier that is

attached to the verb is also responsible for its (in)transitivity: a Handling Classifier turns a (basically intransitive) verb into a transitive verb.

6.4 ISL Classifiers

6.4.1 ISL Classifier Handshapes

Figure 6.2, taken from O’Baill and Matthews (2000), provides the classifier handshapes identified within ISL. McDonnell (1996: 4) identifies four categories of movement for ISL classifier predicates: ‘MOVE signifies an entity’s own motion or motion caused by an external agent. BE-LOCATED denotes the location of an entity. EXIST indicates the presence of an entity without any particular reference to its location. EXTENT indicates the shape and/or dimensions of an entity’.



Figure 6.2 The classifier handshapes of ISL, O’Baill and Matthews (2000: 118-119)

6.4.2 ISL Classifier Categories

McDonnell (1996) incorporates six categories of classifier handshapes identified by Brennan (1992) and identifies the four broader categories of classifier predicates used in ISL Table 6.4, previously illustrated in chapter 2 (Leeson and Saeed (2012)).

Table 6.4 ISL classifier predicate categories, based on Leeson and Saeed (2012: 110)

Category	Description
Whole entity-CL stems	Includes discussion of hand configurations that refer to semantic size and shape, and instrumental categories
Extension-CL stems	Includes reference to tracing size and shape configurations
Handle entity-CL stems	Includes reference to handling and touch categories
Body-CL stems	Where the signer's body functions in a way that is similar to the way that handshapes function in certain two-handed configurations.

6.4.1.1 Whole Entity-CL Stems

In these classifier stems, the hand configuration typically represents an entire entity. Leeson and Saeed (2012) describe how several subcategories of whole entity-CL stems have been identified within ISL. A semantic-CL stem refers to an entity in terms of its semantic features (for example, + animate). A size and shape-CL stem refers to an entity in terms of its shape (for example, square). McDonnell (1996) proposes that these type of stems can combine with the same types of movement in ISL such as MOVE, BE-LOCATED and EXIST. McDonnell (ibid.) identifies a multiple entity-CL handshape in ISL identifiable as '5-hand/s' referring to the signer's fingers being open and spread. This handshape refers to multiple entities as members of large groups and is an example of a classifier in ISL being used to quantify. These classifiers seem to correlate with the Whole Entity Classifier group, which has been distinguished for most of the SLs that have been described to date.

6.4.1.2 Extension-CL Stems

Extension-CL stems trace rather than represent entities that they refer to. These CL stems only combine with EXTENT movements. Leeson and Saeed refer to Brennan (1992), where a similar 'tracing size and shape classifier' was defined for BSL.

6.4.1.3 Handle Entity-CL Stems

Leeson and Saeed (2012) refer to the use of handle entity-CL stems as indicating an animate actor. These entity-CL stems have “handshapes that typically denote the configuration of the hand as it moves, touches or uses an object, or part of an object” rather than the object as a whole.

6.4.1.4 Body-CL Stems

Leeson and Saeed (2012) refer to the use of this category of stem where “the signer’s body functions in a way that is similar to the way that handshape functions in two-handed configurations. Typically the body classifier involves the body of the signer and is used as an independent articulator and is used to refer to a single animate entity, which is typically an individual”.

6.5 ISL Classifier Verbs and Morphological Complexity

Classifier predicates differ from the other main verb categories in sign language because the handshape functions as a morpheme and also as a “classifier”. Classifier handshapes combine with various types of movement morphemes, and there are morphosyntactic constraints on these combinations (Supalla, 1982).

Zwitserslood (2012) identifies Whole Entity classifiers as classifiers that represent the referent directly and are seen in verbs that express a motion of a referent, its localisation in space or its existence in space. As an example of the morphological complexity of ISL classifiers we refer to the vehicle or the object classifier. O’Baill and Matthews (2000), define this type of classifier within ISL as inanimate semantic classifiers. The operation of classifiers in ISL proves similar to other SLs as identified by Zwitserslood (2012), where a referent is initially introduced by a noun in the citation form of the lexical item. This noun is then followed by a verb with a classifier representing the referent of the noun. Zwitserslood (ibid.) points out that when representing more than one entity in space, the bigger/backgrounded entity is introduced first and then the smaller entity, which is in the focus of attention is introduced. As discussed previously in section 2.6.4 Vermeerbergen et al. (2007: 1) outline the complexity of simultaneity in SLs, describing how SL users can choose on a range of articulators when articulating a linguistic message.

Vermeerbergen et al. (2007: 1) identify that these articulators can work together to produce one lexical item or they can work to convey different types of information. This can include simultaneously using the two hands as two separate “parallel autonomous channels”, with one hand encoding signs distinct from the other hand.

Baoill and Matthews (2002) provide a brief illustration of the operation of a Whole Entity classifier in ISL in the articulation of the ISL sentence “The car is moving”. Figure 6.3 taken from O’ Baoill and Matthews (2000) provides an illustration of the sentence in ISL. In this instance, the citation form of the sign CAR is articulated followed by the vehicle classifier handshake. This handshake can be referred to as the [18] handshake in ISL. O’ Baoill and Matthews describe how the rest of the information necessary to complete the sentence follows the classifier. The simultaneous articulation of NMF’s together with the handshake, orientation, movement and/or movement along a path are used to provide further information.

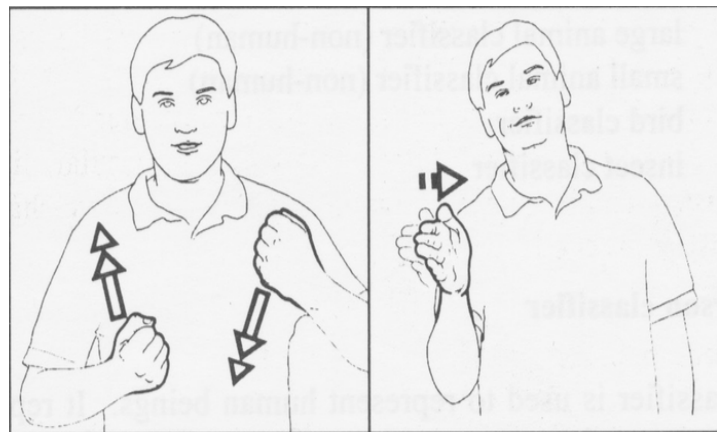


Figure 6.3 ISL sentence: 'The car is moving', OBaoill and Matthews (2000: 69)

The orientation of the palm represents information pertaining to the location in space, while the direction of movement from one point in space to another encodes information relating to motion and manner. Similar to Paddens (1988) description of spatial verbs, whole entity classifier verbs could be likened to spatial verbs, which can be described as a class of verbs denoting motion and location in space, encoding the locations of locative arguments, the source and the goal based on the direction of movement of the hands. The shape of the path movement the hands are tracing is said to often depict the shape of the path that an object traverses in space.

The classifier verb allows for a *classifier* specification, using this as an agreement marker of the noun argument to the verb root. The ISL inanimate whole entity classifier itself may behave as a morphologically complex unit as opposed to a single morpheme. An example of this is displayed in the sentence extracted from the Signs of Ireland corpus “the jeep crashed into the back of the car”, where the fingertips in the vehicle classifier handshape [18] represent the front of the car and also the relative positioning in space (forward facing) and also the direction of movement (forward). The rear or the palm represents the back of the vehicle and also the relative positioning in space. The classifier handshape [18] representing the jeep changes from the vehicle handshape [18] to classifier handshape [4]. While in handshape [18] the vehicle classifier for the jeep represented the direction of movement and location in space behind the other vehicle This representation of the jeep as a normal vehicle [18] is on impact with the vehicle in front altered and the jeep is represented by a different classifier handshape [4] representing that the shape of the jeep is now altered. Information is also provided in terms of the fact that the jeep as an object is now physically crashed as well as representing the action that has occurred (that of crashing into back of the vehicle located in front).

The classifier verb allows for a phonological feature *movement* specification in terms of the classifier for movement from a location (a) to a location (b) in 3D space.

The classifier verb allows for a specification for *manner* of the phonological feature movement/motion of the classifier using both MF and NMF.

The classifier verb allows for a specification for the phonological feature *orientation* of the palm, which encodes information relating to the location in space of the classifier.

6.6 Analysing ISL Classifiers

On investigation of ISL classifiers with ISL verbs and the associated Aktionsart classes it was found that the ISL verbs that occur with classifiers show linguistic correlates for five situation types: states, activities, achievements, accomplishments and semelfactives, similar to ISL verbs with associated Aktionsart classes analysed in chapter 5. Table 6.5 illustrates various ISL sentences taken from the SOI corpus.

The verbs are categorised according to tripartite verb class or as classifier verbs. They are also categorised according to transitivity and situation type. The RRG Logical Structure for the verb is then provided based on the event/situation type with information necessary to represent the semantics of classifiers in terms of ISL logical structures.

6.7 Representing ISL Classifiers and Classifier Verbs within the RRG Lexicon

Taking all of the information in this chapter in relation to ISL classifiers into account and based on our analysis of ISL classifiers, we propose an RRG logical structure in terms of ISL classifiers and classifier verbs as follows.

6.7.1 ISL Whole Entity (Person Two Legs) Classifier

Example 6.1

(BOY) V-CL+c+MOVE+f+hi

‘The boy went upstairs’

McDonnell (1996: 204) Example 6.38

The ^xlocus namely ^x is the undergoer ‘the boy’. This ^xlocus is associated with the boy or the undergoer (^xBOY), which is articulated in a lexical sign for BOY.

The classifier handshape [47], in Figure 6.2, (which is categorised in ISL as an +animate V-CL classifier) is represented as the ^{xa}BOY entry in the LS. The *x* in this case is used to associate the ^{xa}BOY classifier with the undergoer of the previously introduced (^xBOY). This ^x denotes that the classifier now depicts and is a reference to the BOY. The ^a in the ^{xa}BOY LS entry denotes the reference to classifier handshape [47] now representing the BOY entity in this phrase. This ^b denotes the stairs that the boy goes up.

In Table 6.5, we illustrate an analysis of the ISL sentence defining the ISL verb class, verb transitivity, Aktionsart class, classifier type. We then provide the RRG+Sign_A rich logical structure in Example 6.2.

Table 6.5 Analysis of ISL sentence person index up classifier

Verb Class	Transitivity	Aktionsart Class	Classifier Type
classifier	transitive	activity	Whole Entity +animate two legs

Example 6.2

(BOY) V-CL+c+MOVE+f+hi

‘The boy went upstairs’

McDonnell (1996: 204) Example 6.38

do'(^xBOY, [^{xa}V-CL+c+**MOVE**^{bi} <TLine><MF><NMF> (^{xa}BOY, ^bf+hi)])

<LHS> Classifier[47] V bent fingers

<SSL> L4_mid (Location at signer's chest)

<HMOV> from locus point ^a to locus point ^b

<ORI> forward

6.7.2 ISL Whole Entity (Person Two Legs) Classifier

Example 6.3



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’

SOI Corpus Orla (04) Personal Stories (Dublin)

In Example 6.4, the classifier handshape [47], in Figure 6.2, (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 ^blocus (^bthe 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.

Table 6.6, illustrates an analysis of the ISL sentence, defining the ISL verb class, verb transitivity, Aktionsart class, classifier type and Example 6.4 provides the RRG logical structure.

Table 6.6 Analysis of ISL sentence person two legs classifier

Verb Class	Transitivity	Aktionsart Class	Classifier Type
Classifier [47] V bent fingers	intransitive	activity	Whole Entity +animate two legs

Example 6.4

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. orientation-sr+hi^b)

<RHS> rhDef[((f1Shape_i: f1Shape_n, eventDuration(ti, tn)),(f2Shape_i: f2Shape_n, eventDuration(ti, tn)), (f3Shape_i: f3Shape_n, eventDuration(ti, tn)), (f4Shape_i: f4Shape_n, eventDuration(ti, tn)), (tShape_i:tShape_n, eventDuration(ti, tn)), timeLine(ti, tn)), (tOverlap_i:tOverlap_n, eventDuration(ti, tn)), timeLine(ti, tn)), (tPalm_i:tPalm_n, eventDuration(ti, tn)), timeLine(ti, tn))]

<LHS> lhDef[((f1Shape_i: f1Shape_n, eventDuration(ti, tn)),(f2Shape_i: f2Shape_n, eventDuration(ti, tn)), (f3Shape_i: f3Shape_n, eventDuration(ti, tn)), (f4Shape_i: f4Shape_n, eventDuration(ti, tn)), (tShape_i:tShape_n, eventDuration(ti, tn)), timeLine(ti, tn)), (tOverlap_i:tOverlap_n, eventDuration(ti, tn)), timeLine(ti, tn)), (tPalm_i:tPalm_n, eventDuration(ti, tn)), timeLine(ti, tn))]

<SSL> [((L4_mid /*(neutral space in front of signer)*/, eventDuration (ti,tn), timeLine (ti, tn)))]

<AMOV> LH[aMDef((locus xi,yi,zi: xn,yn,zn || SSLDef: SSLDef|| **circular**), eventDuration(t1, tn), timeline(ti,tn), hsDef, wDef, pODef, fADef, uADef)]
RH[aMDef((locus xi,yi,zi: xn,yn,zn || SSLDef: SSLDef|| **circular**), eventDuration(t1, tn), timeline(ti,tn), hsDef, wDef, pODef, fADef, uADef)]

<ORI> poDef [LH ((xi,yi,zi: xn, yn, zn), eventDuration (ti,tn), timeLine (ti, tn))],
[RH ((xi,yi,zi: xn, yn, zn), eventDuration (ti,tn), timeLine (ti, tn))]

<EG> [left, eventDuration (ti,tn), timeLine (ti, tn)]

Note: <LOCUS> (^{xa}locus: handshape reference to husband introduced earlier) (^blocus: reference to “the area” being explored).

6.7.3 ISL Whole Entity (Person Index Up) Classifier

Example 6.5

dh: I SEE TWO GIRL Index-CL+MOVE-towards-fl+EXIST+orientation-sl

nh: Index-CL+MOVE-towards-c+EXIST+orientation-sr

‘I saw two girls approach each other’

O’Baioill and Matthews (2000: 73) Figure 5.10

Table 6.7, illustrates an analysis of the ISL sentence. We define the ISL verb transitivity, Aktionsart class, classifier type. Example 6.6 provides the RRG logical structure.

Table 6.7 Analysis of ISL sentence person index up classifier

Verb Class	Transitivity	Aktionsart Class	Classifier Type
plain	transitive	state	-
classifier	transitive	activity	Whole Entity +animate index up

Example 6.6

(a) I SEE TWO GIRL

‘I saw two girls’

(b) dh:Index-CL+MOVE-towards-fl+EXIST+orientation-sl

nh:Index-CL+MOVE-towards-c+EXIST+orientation-sr

‘approach each other’

SEE’<TLine><MF><NMF> (1sg, ^xGIRL.pl)

do’(^{xa} index-CL. index-CL, [^{ab} **MOVE-towards-c.MOVE-towards-**

c’<Tline><MF><NMF> (^{xa} index-CL. index-CL, ^bEXIST+c+orientation-sl.EXIST+c+orientation-sr]))

<HS> Classifier[24] index finger up on both hands
 <LOC> (^{ab}locus: to signer's right and left respectively) (^clocus: location in front of signer) // marks for location
 <MOV> from points on left and right of signer's body out to point in space in front of signer
 <ORI> palm facing one another as circular movement progresses

The ^xlocus namely ^xGIRL.pl from Example 6.6(a) is the undergoer of the ISL verb SEE. This ^xlocus is associated with the girls or the undergoer (^xGIRL.pl), which is articulated in a lexical sign for girl, with the one hand in the [24] shape, in Figure 6.2, with the palm facing towards signer's face and index finger moving down from cheek bone to chin.

In Example 6.6(b) classifier handshape [24], in Figure 6.2, (which is categorised in ISL as an +animate index up whole entity classifier and used in this case to represent a human person) represents the ^{xa}GIRL.pl entry in the LS. The ^x in this case is used to associate the ^{xa} index-CL.index-CL classifier in Example 6.6(b) with the undergoer of the previous phrase (^xGIRL.pl) in Example 6.6(a). This ^x denotes that the classifier now depicts and is a reference to the girls undergoer/object/entity previously articulated. The ^a in the ^{xa} index-CL.index-CL LS entry denotes the reference to classifier handshape [24] (on both hands), in Figure 6.2, now representing the girls in this phrase. This classifier handshape argument represents the theme or subject of the activity in this case with depiction of the movement of two animate entities in space moving towards the ^blocus location, which is actually towards one another in this example. In this case the two upward facing index fingers of the left and right hand move with palms facing one another from the location to the signer's right and left side respectively to stop short of contact in front of the signer, with the ^blocus referring to this.

6.7.4 ISL Whole Entity (animate entity) Classifier

Example 6.7



head nod

dh: LARGE ANIMAL-CL+BE-LOCATED+f+MOVE+c

nh: LARGE ANIMAL-CL+BE-LOCATED+f+MOVE+c

‘The deer stood there looking angry’

SOI Corpus Fergus D. (06) Personal Stories (Dublin)

In Example 6.8, the classifier handshape [55], in Figure 6.2, (which is categorised in ISL as an +animate large animal whole entity classifier) is represented as the ^{xa}locus entry in the LS. The x in this case is used to associate the ^{xa}deer LS entry with the entity introduced earlier in the discourse i.e. the deer. This ^x denotes that the classifier now depicts and is a reference to the deer (a type of large animal). The ^a in the ^{xa}3sg LS entry denotes the reference to classifier handshape [55] in Figure 6.2, now representing the deer entity. This classifier handshape argument represents the theme or subject of the activity and is used to denote the deer who is positioned looking angry. The NMF of a closed mouth and crinkled nose, together with the forward movement and repeated headnod denote that the deer was angry.

Table 6.8 illustrates an analysis of the ISL defining the ISL verb class, verb transitivity, Aktionsart class and classifier type. The RRG+Sign_A logical structure is provided in Example 6.8.

Table 6.8 Analysis of ISL large animal classifier

Verb Class	Transitivity	Aktionsart Class	Classifier Type
classifier	intransitive	activity	Whole Entity +animate

Example 6.8

_____ head nod

dh: large-animal-CL+BE-LOCATED+f+MOVE+c

nh: large-animal-CL+BE-LOCATED+f+MOVE+c

‘The deer stood there looking angry’

SOI Corpus Fergus D. (06) Personal Stories (Dublin)

do' (^aDEER, [^a LARGE ANIMAL-CL+BE-LOCATED+f^{b'} <TLine><MF><NMF> (^{xa}
LARGE ANIMAL-CL, ^b BE-LOCATED+f)])

<**RHS**> rhDef[((f1Shape_i: f1Shape_n, eventDuration(ti, tn)), (f2Shape_i: f2Shape_n, eventDuration(ti, tn)), (f3Shape_i: f3Shape_n, eventDuration(ti, tn)), (f4Shape_i: f4Shape_n, eventDuration(ti, tn)), (tShape_i:tShape_n, eventDuration(ti, tn)), timeLine(ti, tn)), (tOverlap_i:tOverlap_n, eventDuration(ti, tn)), timeLine(ti, tn)), (tPalm_i:tPalm_n, eventDuration(ti, tn)), timeLine(ti, tn))]

<**LHS**> lhDef[((f1Shape_i: f1Shape_n, eventDuration(ti, tn)), (f2Shape_i: f2Shape_n, eventDuration(ti, tn)), (f3Shape_i: f3Shape_n, eventDuration(ti, tn)), (f4Shape_i: f4Shape_n, eventDuration(ti, tn)), (tShape_i:tShape_n, eventDuration(ti, tn)), timeLine(ti, tn)), (tOverlap_i:tOverlap_n, eventDuration(ti, tn)), timeLine(ti, tn)), (tPalm_i:tPalm_n, eventDuration(ti, tn)), timeLine(ti, tn))]

<**SSL**> [((L4_mid /*(neutral space in front of signer)*/, eventDuration (ti,tn), timeLine (ti, tn)))]

<**AMOV**> LH[aMDef((**locus xi,yi,zi: xn,yn,zn** || SSLDef: SSLDef|| circular), eventDuration(t1, tn), timeline(ti,tn), hsDef, wDef, pODef, fADef, uADef)]
RH[aMDef((**locus xi,yi,zi: xn,yn,zn** || SSLDef: SSLDef|| **circular**), eventDuration(t1, tn), timeline(ti,tn), hsDef, wDef, pODef, fADef, uADef)]

<**ORI**> poDef([LH ((xi,yi,zi: xn, yn, zn), eventDuration (ti,tn), timeLine (ti, tn))], [RH ((xi,yi,zi: xn, yn, zn), eventDuration (ti,tn), timeLine (ti, tn))])

<**EG**> [forward, eventDuration (ti,tn), timeLine (ti, tn)]

<**MTH**> [closed_tight, eventDuration(ti, tn), timeLine(ti, tn)]

<**NSE**> [crinkled, eventDuration(ti, tn), timeLine(ti, tn)]

<**HEAD**> [nod, eventDuration(ti, tn) **repeat**, timeLine(ti, tn)]

Note: <LOCUS> (^{xa}locus: handshape reference to deer introduced earlier) (^blocus: reference to the deer standing “there”)

6.7.5 ISL Whole Entity (animate entity) Classifier

Example 6.9



_____puffed cheeks

dh: V-CL+MOVE+JUMP-UP-AND-OVER

nh: Thin-vertical-entity-CL+EXIST-----

‘The dog jumped (out the window)’

SOI Corpus Fergus D. (06) Frog Story (Dublin)

We define the transitivity, Aktionsart class, classifier type and also the RRG logical structure.

Table 6.9 Analysis of ISL sentence animate entity two legs classifier

Verb Class	Transitivity	Aktionsart Class	Classifier Type
classifier	intransitive	semelfactive	Whole Entity +animate

In Example 6.10, the classifier handshape [47], in Figure 6.2, is represented as the ^{xa}locus entry in the LS. The x in this case is used to associate the ^{xa} LS entry with the entity introduced earlier in the discourse i.e. the dog. This ^x denotes that the classifier now depicts and is a reference to the dog. The ^a in the ^{xa}dog LS entry denotes the reference to classifier handshape [47], in Figure 6.2, now representing the dog entity. This classifier handshape argument represents the theme or subject of the semelfactive verb jump and is used to denote the the dog jumped up and over, with the tips of the fingers denoting the paws of the dog.

Example 6.10

puffed cheeks

dh:V-CL+MOVE+JUMP-UP-AND-OVER

nh: Flat-surface-entity-CL+EXIST-----

‘The dog jumped out (the window)’

SEML ^{xa} MOVE+JUMP-UP-AND-OVER ^{b'} <TLine><MF><NMF> (^{xa}V-CL, Flat-surface-entity-CL+EXIST-----^b)

<RHS> rhDef[(f1Shape_i: f1Shape_n, eventDuration(ti, tn)), (f2Shape_i: f2Shape_n, eventDuration(ti, tn)), (f3Shape_i: f3Shape_n, eventDuration(ti, tn)), (f4Shape_i: f4Shape_n, eventDuration(ti, tn)), (tShape_i:tShape_n, eventDuration(ti, tn)), timeLine(ti, tn)), (tOverlap_i:tOverlap_n, eventDuration(ti, tn)), timeLine(ti, tn)), (tPalm_i:tPalm_n, eventDuration(ti, tn)), timeLine(ti, tn))]

<LHS> lhDef[(f1Shape_i: f1Shape_n, eventDuration(ti, tn)), (f2Shape_i: f2Shape_n, eventDuration(ti, tn)), (f3Shape_i: f3Shape_n, eventDuration(ti, tn)), (f4Shape_i: f4Shape_n, eventDuration(ti, tn)), (tShape_i:tShape_n, eventDuration(ti, tn)), timeLine(ti, tn)), (tOverlap_i:tOverlap_n, eventDuration(ti, tn)), timeLine(ti, tn)), (tPalm_i:tPalm_n, eventDuration(ti, tn)), timeLine(ti, tn))]

<SSL> [(L4_mid /*(neutral space in front of signer)*/, eventDuration (ti,tn), timeLine (ti, tn))]

<AMOV> LH[aMDef((locus xi,yi,zi: xn,yn,zn || SSLDef: SSLDef|| circular|| upward), eventDuration(t1, tn), timeline(ti,tn), hsDef, wDef, pODef, fADef, uADef)]
RH[aMDef((locus xi,yi,zi: xn,yn,zn || SSLDef: SSLDef|| circular|| upward), eventDuration(t1, tn), timeline(ti,tn), hsDef, wDef, pODef, fADef, uADef)]

<ORI> poDef([LH ((xi,yi,zi: xn, yn, zn), eventDuration (ti,tn), timeLine (ti, tn))], [RH ((xi,yi,zi: xn, yn, zn), eventDuration (ti,tn), timeLine (ti, tn))])

<EG> [followLHand, eventDuration (ti,tn), timeLine (ti, tn)]

<RCHK> [blow, eventDuration (ti,tn), timeLine (ti, tn)]

<LCHK> [blow, eventDuration (ti,tn), timeLine (ti, tn)]

<MTH> [closed_tight, eventDuration(ti, tn), timeLine(ti, tn)]

Note: <LOCUS> (^{xa}locus: handshake reference to dog introduced earlier) (^blocus: reference to jumping up and over or off the bed)

6.7.6 ISL Whole Entity (inanimate entity) Classifier

Example 6.11

(CAR) Vehicle-CL+f+MOVE+orientation-c

BODY-CL+EXIST

‘The car drove past me’

O’Baioill and Matthews (2000: 83) Figure 5.3

In Example 6.12, the classifier handshape [18], from Figure 6.2, (which is categorised in ISL as an inanimate whole entity vehicle classifier) is represented as the ^{xa}locus entry in the LS. The *x* in this case is used to associate the ^{xa} LS entry with the entity introduced earlier i.e. the car. This ^x denotes that the classifier now depicts and is a reference to the car. The ^a in the ^{xa}car LS entry denotes the reference to classifier handshape [18] now representing the car entity. This classifier handshape argument represents the theme or subject and is used to denote the car driving past the front of the signer’s body, where the locus of the signer’s body is used to refer to ‘me’. This locus is provided for using location L1 within the Articulatory Structure Level signing allocation map from Figure 4.12.

Table 6.10 illustrates an analysis of the ISL sentence defining the ISL verb class, verb transitivity, Aktionsart class, classifier type. The RRG+Sign_A logical structure is provided in Example 6.12.

Table 6.10 Analysis of ISL sentence vehicle classifier

Verb Class	Transitivity	Aktionsart Class	Classifier Type
classifier	intransitive	activity	Whole Entity -animate vehicle

Example 6.12

do’(^aCAR, [^{ab’}+f+MOVE+orientation-c <TLine><MF><NMF> (^{xa}Vehicle-CL,
^bBODY-CL+EXIST))])

<RHS> rhDef[((f1Shape_i: f1Shape_n, eventDuration(ti, tn)), (f2Shape_i: f2Shape_n, eventDuration(ti, tn)), (f3Shape_i: f3Shape_n, eventDuration(ti, tn)), (f4Shape_i: f4Shape_n, eventDuration(ti, tn)), (tShape_i: tShape_n, eventDuration(ti, tn)), timeLine(ti, tn)), (tOverlap_i: tOverlap_n, eventDuration(ti, tn)), timeLine(ti, tn)), (tPalm_i: tPalm_n, eventDuration(ti, tn)), timeLine(ti, tn))]

<LHS> lhDef[(f1Shape_i: f1Shape_n, eventDuration(ti, tn)), (f2Shape_i: f2Shape_n, eventDuration(ti, tn)), (f3Shape_i: f3Shape_n, eventDuration(ti, tn)), (f4Shape_i: f4Shape_n, eventDuration(ti, tn)), (tShape_i: tShape_n, eventDuration(ti, tn)), timeLine(ti, tn)), (tOverlap_i: tOverlap_n, eventDuration(ti, tn)), timeLine(ti, tn)), (tPalm_i: tPalm_n, eventDuration(ti, tn)), timeLine(ti, tn))]

<SSL> [((L4_mid /*(neutral space in front of signer)*/, eventDuration (ti,tn), timeLine (ti, tn)))]

<AMOV> LH[aMDef((locus xi,yi,zi: xn,yn,zn || SSLDef: SSLDef|| circular|| upward), eventDuration(t1, tn), timeline(ti,tn), hsDef, wDef, pODef, fADef, uADef)]
RH[aMDef((locus **xi,yi,zi: xn,yn,zn** || SSLDef: SSLDef|| circular|| upward), eventDuration(t1, tn), timeline(ti,tn), hsDef, wDef, pODef, fADef, uADef)]

<ORI> poDef([LH ((xi,yi,zi: xn, yn, zn), eventDuration (ti,tn), timeLine (ti, tn))], [RH ((xi,yi,zi: xn, yn, zn), eventDuration (ti,tn), timeLine (ti, tn))])

<EG> [followRHand, eventDuration (ti,tn), timeLine (ti, tn)]

Note: <LOCUS> (^alocus: handshape reference to car introduced earlier) (^blocus: reference to signer)

6.7.7 ISL Whole Entity (inanimate entity) Classifier

Example 6.13



dh: Vehicle-CL+MOVE+sl+contact left hand

nh: Vehicle-CL+EXIST+base of palm -----

‘The jeep crashed into the back of the car’.

SOI Corpus Nicholas (22) Personal Stories (Wexford)

Table 6.11 illustrates an analysis of the ISL sentence defining the ISL verb class, verb transitivity, Aktionsart class and classifier type. The RRG+Sign_A logical structure is provided in Example 6.14.

Table 6.11 Analysis of ISL sentence vehicle classifier

Verb Class	Transitivity	Aktionsart Class	Classifier Type
classifier	transitive	activity	Whole Entity -animate vehicle

In Example 6.14, the classifier handshape [18], from Figure 6.2, (which is categorised in ISL as an inanimate whole entity vehicle classifier) is represented as the ^{xa}locus entry in the LS. The *x* in this case is used to associate the ^{xa} LS entry with the entity introduced earlier in the discourse i.e. the jeep. The ^a in the ^{xa} jeep LS entry denotes the reference to classifier handshape [18] now representing the jeep entity. This classifier handshape argument represents the theme or subject and is used to denote the the movement and subsequent crashing into a car. Semantic change in terms of the jeep is represented by a change of handshape from the [18] handshape, in Figure 6.2, to the [4] handshape, in Figure 6.2. The jeep is represented by the dominant hand and the car by the non-dominant hand.

Example 6.14

dh: Vehicle-CL+MOVE+sl+contact left hand

nh: Vehicle-CL+EXIST+base of palm -----

‘The jeep crashed into the car’

do'(^avehicle-CL, [^a**MOVE+sl+contact left hand**^{b'}<TLine><MF><NMF>
(^{xa}vehicle-CL, ^b vehicle CL+EXIST+base of palm)

<**RHS**> rhDef[(f1Shape_i: f1Shape_n, eventDuration(ti, tn)),(f2Shape_i: f2Shape_n, eventDuration(ti, tn)), (f3Shape_i: f3Shape_n, eventDuration(ti, tn)), (f4Shape_i: f4Shape_n, eventDuration(ti, tn)), (tShape_i:tShape_n, eventDuration(ti, tn)), timeLine(ti, tn)), (tOverlap_i:tOverlap_n, eventDuration(ti, tn)), timeLine(ti, tn)), (tPalm_i:tPalm_n, eventDuration(ti, tn)), timeLine(ti, tn))]

<**LHS**> lhDef[(f1Shape_i: f1Shape_n, eventDuration(ti, tn)),(f2Shape_i: f2Shape_n, eventDuration(ti, tn)), (f3Shape_i: f3Shape_n, eventDuration(ti, tn)), (f4Shape_i: f4Shape_n, eventDuration(ti, tn)), (tShape_i:tShape_n, eventDuration(ti, tn)), timeLine(ti, tn)), (tOverlap_i:tOverlap_n, eventDuration(ti, tn)), timeLine(ti, tn)), (tPalm_i:tPalm_n, eventDuration(ti, tn)), timeLine(ti, tn))]

<**SSL**> [((L4_mid /*(neutral space in front of signer)*/, eventDuration (ti,tn), timeLine (ti, tn)))]

<**AMOV**> LH[aMDef((**locus xi,yi,zi: xn,yn,zn** || SSLDef: SSLDef|| circular|| upward), eventDuration(t1, tn), timeline(ti,tn), hsDef, wDef, pODef, fADef, uADef)]
RH[aMDef((**locus xi,yi,zi: xn,yn,zn** || SSLDef: SSLDef|| circular|| upward), eventDuration(t1, tn), timeline(ti,tn), hsDef, wDef, pODef, fADef, uADef)]

<ORI> poDef([LH ((xi,yi,zi: xn, yn, zn), eventDuration (ti,tn), timeLine (ti, tn))],
 [RH ((xi,yi,zi: xn, yn, zn), eventDuration (ti,tn), timeLine (ti, tn))])
 <EG> [followRHand, eventDuration (ti,tn), timeLine (ti, tn)]

Note: <LOCUS> (^{xa}locus: handshake reference to jeep introduced earlier) (^blocus: reference to car that the jeep crashes into

6.7.8 ISL Whole Entity (inanimate entity) Classifier

Example 6.15

Vehicle-CL+BE-LOCATED+sr₁+BE-LOCATED+sr₂+BE-LOCATED+sr₃+BE-
 LOCATED+sr₄

‘The vehicles were parked in a row’

McDonnell (1996: 212) Example 6.74

In Example 6.16, the classifier handshape [18], from Figure 6.2, (which is categorised in ISL as an inanimate whole entity vehicle classifier) is represented as the ^xlocus entry in the LS. This ^x denotes that the classifier depicts and is a reference to a vehicle entity. This classifier handshape argument represents the theme or subject and is used to denote the vehicles are parked in a row, which is depicted in signing space to the signer’s right in signing space. This locus is provided for using location L4_mid or L4_upper within the Articulatory Structure Level signing allocation map from Figure 4.12.

Table 6.12 illustrates an analysis of the ISL sentence defining the ISL verb class, transitivity, Aktionsart class and classifier type. The RRG+Sign_A rich logical structure is provided in Example 6.16.

Table 6.12 Analysis of ISL sentence vehicle classifier

Verb Class	Transitivity	Aktionsart Class	Classifier Type
classifier	transitive	state	Whole Entity -animate vehicle

Example 6.17

Vehicle-CL+BE-LOCATED+sr₁+BE-LOCATED+sr₂+BE-LOCATED+sr₃+BE-LOCATED+sr₄

‘The vehicles were parked in a row’

McDonnell (1996: 212) Example 6.74

BE-LOCATED’ <TLine><MF><NMF> (Vehicle-CL, sr₁ sr₂ sr₃ sr₄)

<RHS> rhDef(((f1Shape_i: f1Shape_n, eventDuration(ti, tn)),(f2Shape_i: f2Shape_n, eventDuration(ti, tn)), (f3Shape_i: f3Shape_n, eventDuration(ti, tn)), (f4Shape_i: f4Shape_n, eventDuration(ti, tn)), (tShape_i:tShape_n, eventDuration(ti, tn)), timeLine(ti, tn)), (tOverlap_i:tOverlap_n, eventDuration(ti, tn)), timeLine(ti, tn)), (tPalm_i:tPalm_n, eventDuration(ti, tn)), timeLine(ti, tn))]

<LHS> lhDef(((f1Shape_i: f1Shape_n, eventDuration(ti, tn)),(f2Shape_i: f2Shape_n, eventDuration(ti, tn)), (f3Shape_i: f3Shape_n, eventDuration(ti, tn)), (f4Shape_i: f4Shape_n, eventDuration(ti, tn)), (tShape_i:tShape_n, eventDuration(ti, tn)), timeLine(ti, tn)), (tOverlap_i:tOverlap_n, eventDuration(ti, tn)), timeLine(ti, tn)), (tPalm_i:tPalm_n, eventDuration(ti, tn)), timeLine(ti, tn))]

<SSL> [((L4_mid /*(space to right of signer))*/, eventDuration (ti,tn), timeLine (ti, tn)))]

<AMOV> LH[aMDef((locus xi,yi,zi: xn,yn,zn || SSLDef: SSLDef|| circular|| upward), eventDuration(t1, tn), timeline(ti,tn), hsDef, wDef, pODef, fADef, uADef)]
RH[aMDef((locus xi,yi,zi: xn,yn,zn || SSLDef: SSLDef|| circular|| upward), eventDuration(t1, tn), timeline(ti,tn), hsDef, wDef, pODef, fADef, uADef)]

<ORI> poDef([LH ((xi,yi,zi: xn, yn, zn), eventDuration (ti,tn), timeLine (ti, tn))], [RH ((xi,yi,zi: xn, yn, zn), eventDuration (ti,tn), timeLine (ti, tn))])

<EG> [followRHand, eventDuration (ti,tn), timeLine (ti, tn)]

6.8 Summary

In this chapter we have addressed a portion of RQ3 by providing a definition for the lexical entries for ISL classifiers within the lexicon. We have provided an account of classifiers in spoken and SLs. We have further examined the literature in relation to SL classifiers to provide an insight into the complexities of these morphologically complex units within ISL. We have provided an account of the ISL handshapes for ISL classifiers. We have also provided an account of the four

different categories of classifier realised within ISL. We have utilised the SOI corpus in the analysis of ISL classifiers identifying specifically the tripartite verb class, transitivity, Aktionsart class, classifier category and RRG logical structures. Using this information we have produced a rich logical structure capable of representing ISL within the lexicon. We refer to the Articulatory Structure Level, an extension to Pustejovsky (1991) and the theory of the GL to cater for the various linguistic phenomena consistent with ISL, a visual gestural language in terms of lexical entries.

7. The Layered Structure of the Noun Phrase of ISL

7.1 Introduction

In this chapter we investigate the ISL noun phrase. We examine ISL nouns and the operators that may modify ISL nouns. We look to the literature to investigate the linguistics of ISL nominals. We begin by examining *locus* and what this term refers to in relation to SL. We examine anaphoric and deictic reference and the mechanics of pronominal reference in ISL. We look to the literature in terms of the behavior of adjectives and determiners with regard to ISL nominals. We examine Pustejovsky's GL theory of qualia and we consider its capabilities in terms of the representation of ISL nouns as lexical entries. We refer to RQ3, and address the question: How might lexical entries look for ISL nouns within the RRG lexicon? We posit a theory for lexical entries for ISL nominals and the layered structure of the noun phrase with regard to ISL using RRG as the underlying theory of grammar.

7.2 Locus

A locus in SL refers to a location in space in which a specific entity has been established (Liddell, 2003). The signer can establish an entity by articulating a lexical sign at a specific location in space. A signer can also produce a sign and then direct eyegaze or point to a location in space (Leeson and Saeed, 2012). Once established an entity can be referred to later in the discourse.

Liddell (1990) describes how locus can also be situated on the signer's body. The location on the body that the locus is situated has been found to have phonological significance. Liddell refers to this as having an articulatory function. Liddell further describes a locus that can have a three dimensional function. In this situation the locus stands for a spatial location. The signing space can be described as a stage on which entities are located. Signer's use classifier predicates to represent real world entities and entities are located in relation to each other as they are in the real world (Leeson and Saeed, 2012). Sutton-Spence and Woll (1999) refer to this a topographical space. Leeson and Saeed (2012) describe how entities can also be assigned a locus on the fingertips, with each fingertip then being activated as a locus that is co-referential with that entity. Figure 7.1, taken from the SOI corpus shows

the signer use the index finger and constructed action to represent a person coming straight up to the signer.



Figure 7.1 ISL articulation: ‘A person came straight up to me’, Signs of Ireland Corpus Valerie (12) Personal Stories (Dublin)

With regard to ISL nominals, similar to other signed languages, the locus or location in space in which an entity has been established holds particular significance in linguistic terms, the location or locus encoding varying degrees of meaning dependent upon the type of *spatial division* we are referring to. Section 7.3 provides an account of the spatial division of signing space for ISL from O’Baill and Matthews (2000).

7.3 Using Space to Express Person and Reference in ISL

O’Baill and Matthews (2000), identify three types of spatial division in ISL defined as *relative location*, *real location* and *conventional location*. *Relative location* refers topographical space as it is defined in the literature. This is the stage-like setting up of people and objects within the signing frame, allowing the signer to refer to the people/objects by means of pointing or *index referencing*. *Real location* is used to capture the type of referencing provided by *it* or *that one* in spoken English and occurs when the person/object is situated within the signer’s view. Finally, *conventional location* refers to the use of the signing space for pronominal reference, equivalent to syntactic space in the literature. Conventional location is used when the referent is not present and articulates pronominal meaning equivalent spoken English *I, you he, she it, him ,her, we, you them* and *they*. Figure 7.2, taken

from O'Baoill and Matthews (2000), illustrates the fixed spatial locations used for ISL pronominal reference.

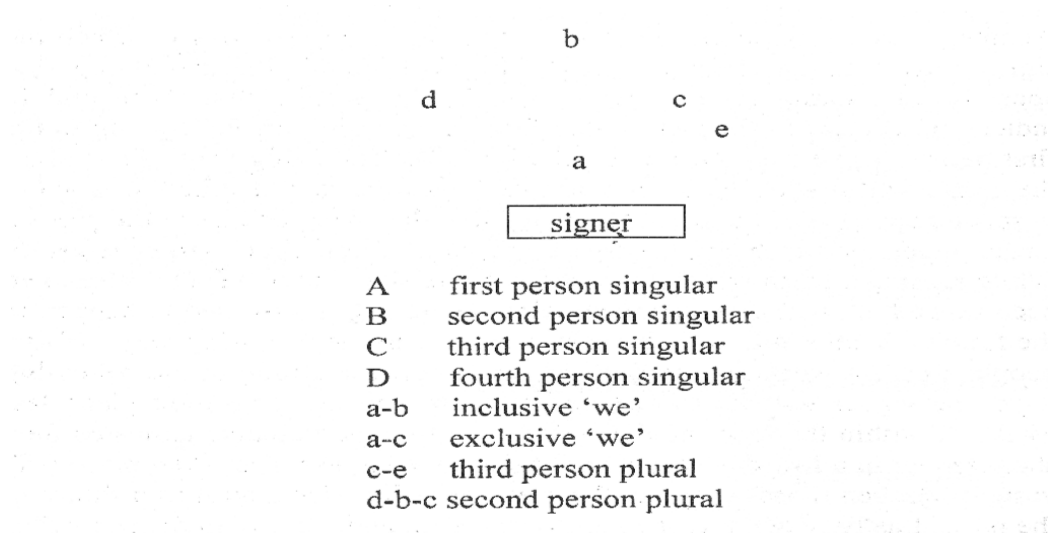


Figure 7.2 Signing space and ISL pronominal reference, O'Baoill and Matthews (2000: 196)

Liddell (2003) provides a separate account of the use of space in ASL as discussed previously in section 2.4.2.

7.4 Pronouns

Cormier (2012) defines pronouns as grammatical items that stand for nouns or noun phrases. Pronouns in signed languages are typically expressed indexically, typically by pointing with the index finger (Schwager and Zeshan, 2008). Not all SLs take this approach however. Cormier (2012) identifies Kata Kolok, a village SL used in Bali as preferring the use of pointing to fingers on the non-dominant hand to articulate pronouns over the use of locations within the signing space. Cormier (2012) also identifies Cambodian Sign Language as preferring the use of full noun phrases over the use of pronominal reference. However, Cormier (ibid.) does concede that in the general majority of SLs studied to date, the space around the signer is used for establishment and maintenance of pronominal (as well as other types of) reference throughout a discourse. Cormier ()

Valli and Lucas (1995) propose that while *location* for ASL classifier constructions and locative verbs provide independent morphological meaning, this is not the case for pronominal reference. They posit that the function of *location* in the pronominal sign itself is articulatory in nature and simply part of the sign with no independent morphological meaning. More recent research work from a cognitive functional perspective proposes that pronominal referencing is motivated (Janzen et al., 2016).

7.4.1 ISL Pronominal Reference

We have seen in Figure 7.2 the fixed signing space locations for pronominal reference within ISL discourse. Pronominal reference is established to these various spatial locations for anaphoric reference in ISL. Figure 7.3 from O'Baill and Matthews (2000), illustrates pronominal index referencing in ISL.

With regard to glossing, first person is referred to as INDEX+c. YOU/HE/SHE (based on a previously established locus at a particular point in space) is referred to as INDEX+f. Leeson and Saeed (2012) report lexical forms for WE, HE, THEY and WE within ISL, however these are used much less frequently than the index form.

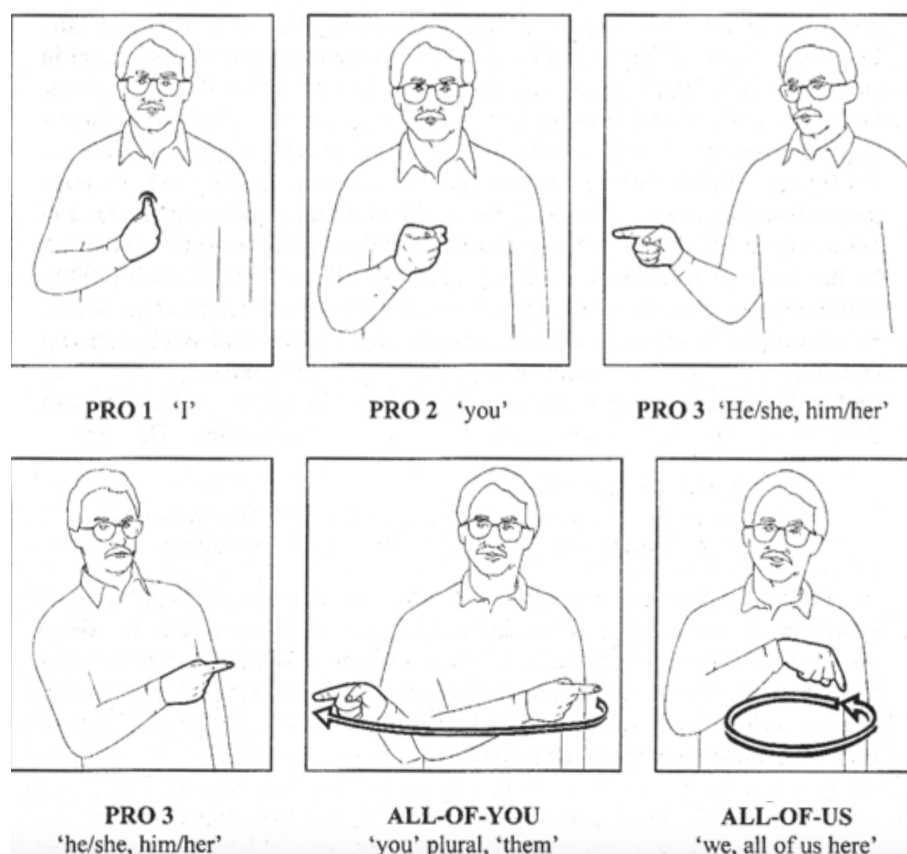


Figure 7.3 ISL pronominal index referencing, O'Baoill and Matthews (2000: 203)

Plural non-first person forms are formed in ISL by moving the pointing sign through a horizontal arc or circular motion in the direction of the referents. Where number is specified, the INDEX handshape is replaced by a numerical handshape, however, the arced or circular motion is maintained. Figure 7.4 and Figure 7.5 illustrate this phenomena, with Figure 7.5 providing an atypical example.

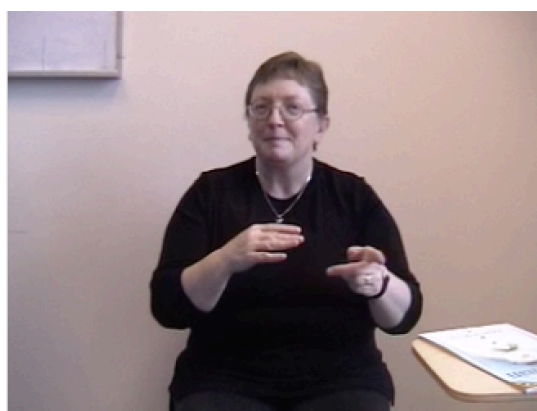


Figure 7.4 ISL articulation: '(I understand) ALL-OF-THEM', Signs of Ireland Corpus Noleen (03) Personal Stories (Dublin)



Figure 7.5 ISL articulation: “TWO-OF-THEM”, Signs of Ireland Corpus Nicholas (22) Personal Stories (Wexford)

7.4.2 The Matter of Person in SL

The issue of person in SLs still remains quite a controversial topic. Meir (1990) argues that while the first person pronoun has a fixed location (in the centre of the chest), second and also third person pronouns could be articulated at any point within the signing space and therefore result in a listability issue. Meir (1990) argues that SLs only show a distinction between first person and non-first person in their pronominal systems. This two-way distinction was challenged by Berenz (2008). She posited the Body Coordinated Model (BCM), in which NMFs are also taken into account. Berenz (1998, 2002) argues that first, second and third person distinctions occur in Brazilian Sign Language (LSB), with second person receiving a much longer eyegaze than third person. Alibasic and Wilbur (2006) have similar findings to Berenz (2002) and posit a three-way system for person in Croatian Sign Language (HZJ). Both of these studies took into account the direction of pointing, the degree that the head turned to follow the indexing and also the direction of the eyegaze non-manual component. Both found an alignment of these three parameters for second person and a non-alignment (of eyegaze) for third person pronouns. In terms of ISL, O’Baill and Matthews (2000) and also Leeson and Saeed (2012) identify a three-way system of person with regard to ISL pronominal reference. This is certainly an area where further research might provide further insights into clarification regarding the role of person.

7.4.3 Number

Cormier (2012) identifies that number marking on pronouns is generally represented by singular, dual and plural forms. Singular is referenced by simply indexing the referent location and dual form by using the index finger and ring finger for the articulation between the two locations being referred to. Also many SLs incorporate numerals to produce number-incorporated pronouns. According to Cormier (2012) number-incorporated pronouns generally have the handshape of the numeral, together with a circular movement towards the group being referred to. Plural forms typically take the form of the ISL index handshape [24] together with a sweeping movement across the locations associated with the referents.

ISL pronouns do show a number difference. Leeson and Saeed (2012) identify that plural non-first person forms are formed by moving the pointing sign through a horizontal arc in the direction of the referents. Inclusive first-person plural pronouns (WE/US) are formed by a downward pointing sign moved in an arc or circular motion between the signer and addressee (s). Where number is specified the index handshape is replaced by a numerical handshape while maintaining the circular motion. Figure 7.6 provides an illustration for the SOI corpus for a numerical handshape in a circular motion referring to the signer and addressee in the articulation of THE-TWO-OF-US.



Figure 7.6 ISL articulation: ‘THE-TWO-OF-US’, Signs of Ireland Corpus Valerie (12) Personal Stories (Dublin)

7.4.4 Constructed Action

Constructed action or role shift occurs in Sign Language when the signer uses ‘his/her face, head, body, hands, and/or other non-manual cues to represent the actions, utterances, thoughts, feelings and/or attitudes of a referent’ (Cormier et al. 2013b: Metzger 1995). Meir and Sandler (2008) identify role/referential shift in Israeli SL by use of the signer’s body/torso as another method of indicating the identity of referents within a particular discourse. The signer tilts the torso in the direction of a specific reference point, which has been pre-assigned to a particular noun. The signer then assumes a referential shift as now having the identity of the referent. From this point the signer, now acting as another entity shifts their body towards another reference point. Figure 7.7 taken from Meir and Sandler (2008), provides an illustration of role/referential shift in Israeli SL.

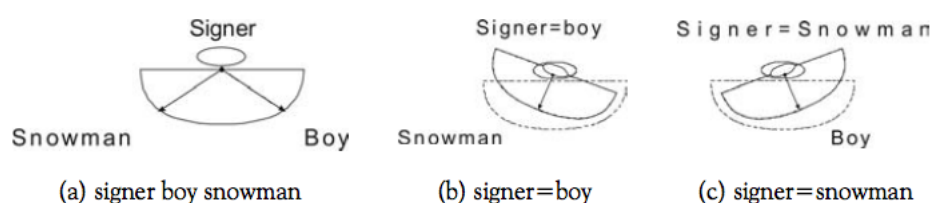


Figure 7.7 Role Shift in Israeli SL, Meir and Sandler (2008: 70)

With regard to ISL, O’Baill and Matthews (2000) identify that role shift/constructed action also occurs, also using topographical space to set the scene to communicate the discourse. Within ISL if there are only two participants involved in the discourse, the signer uses the left and right side of the signing space to represent each participant respectively, similar to Israeli SL. O’Baill and Matthews (2000) report that the defining NMF phonological parameters used to distinguish each participant are tilting of the head and eyegaze upward or downward depending on the conversation. Tilting of the head may also function to represent topographical information regarding the location of each participant to one another. Where more than two participants are part of the discourse index referencing is used to refer to participants. Figure 7.7, taken from the SOI corpus, illustrates role shift where the signer assumes the referential shift to the DOG in the discourse, using head tilt to display the dog as a participant looking upwards towards the boy in the story.



Figure 7.8 ISL role shift 'the dog licked his face', Signs of Ireland Corpus Fergus D. (06) Personal Stories (Dublin)

7.4.5 Possessives



Figure 7.9 ISL articulation MY DAUGHTER, Signs of Ireland Corpus Valerie (12) Personal Stories (Dublin)

The example in Figure 7.9, taken from the SOI corpus, illustrates a possession relation in ISL where the signer is articulating 'my daughter'. Leeson and Saeed (2012) identify possessive relations MY and YOUR as occurring in ISL. The example in figure 7.9 uses the indexing sign, however, in the example in Figure 7.10, taken from the SOI corpus, the signer uses a closed fist directed towards the signer's chest to refer to 'my'.



Figure 7.10 ISL articulation MY JOB, Signs of Ireland Corpus Noeleen (03) Personal Stories (Dublin)

Within ASL, the possessive marker is articulated with an open palm pointing toward the *phi*-location of the possessor. Sutton-Spence and Woll (1999) report that in British Sign Language (BSL) a closed fist is used to refer to possession that is, or could be temporary, while indexation is used for permanent possession.

7.5 ISL Nouns

7.5.1 ISL Noun Reduplication

ISL signs are inflected for grammatical information in similar ways to spoken language and while plural in English nouns is often marked by suffixation of a bound morpheme, for example –s in singular/plural pairs like girl/girls, in other languages plurals are marked by partial or full reduplication. Leeson and Saeed (2012) provide the example of ISL showing the sign for HOUSE, which has been repeated three times HOUSE+++. This communicates the meaning ‘houses’. ISL nouns may be inflected for grammatical information in similar ways to spoken language as discussed in chapter 2.

7.5.2 ISL Adjectives and Colour Terms

ISL nouns may be modified by adjectives and also colour terms, with the adjective typically occurring pre-nominally, where the adjective generally precedes the noun. Example 2.3 in chapter 2 illustrates this. Figure 7.11, taken from the SOI corpus, provides an example of the adjective ‘old’ occurring with a noun ‘woman’ to refer to a nosey elderly lady in the discourse. The articulation occurs as ‘OLD WOMAN’, with the adjective occurring pre-nominally.

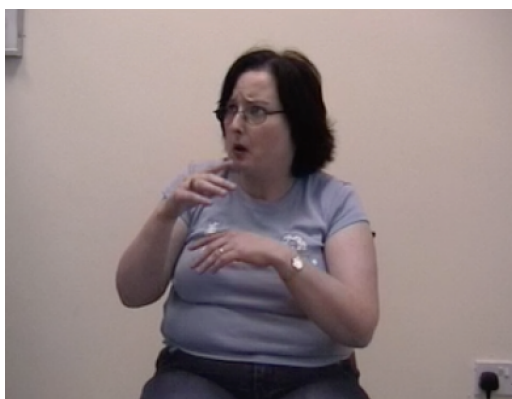


Figure 7.11 ISL articulation OLD WOMAN, Signs of Ireland Corpus Valerie (12) Personal Stories (Dublin), Leeson and Saeed , 2012: 153, Example 7.2h

7.5.3 ISL Quantifiers and the Noun

As discussed in chapter 2, Leeson and Saeed (2012) observe that in ISL only adjectives used to quantify size (BIG and SMALL) occur post-nominally in ISL. The Example below from the SOI corpus illustrates the sign for SMALL in the articulation of the sentence “His small/little dog”.

Example 7.1

- a) HIS DOG SMALL
His small/little dog



Figure 7.12 ISL articulation: ‘His small dog’, Signs of Ireland Corpus Fergus D. (06) Personal Stories (Dublin)

Pfau and Quer (2010) outline the use of NMFs in German Sign Language (DGS) to realise adjectival meaning by providing an example of the adjective small, represented solely by a NMF (cheeks) parameter. This NMF is articulated

simultaneously with a noun (HOUSE) to modify the noun. The example provided was of a signer sucking in their cheeks to demonstrate that a house was smaller than average.

7.5.4 ISL Determiners and the Noun

ISL nouns may combine with determiners to identify a specific entity. Leeson and Saeed (2012) provide the example of THIS and THAT, which is represented by the index handshape [24] and pointing to neutral space in front of the signer. The use of indexing to reference various entities and also in the use of determiners makes it difficult to provide generalisations due to the array of possible functions. Cormier (2012), refers to Bahan et al., (1995) and MacLaughlin (1997) who have argued that in SLs prenominal indexing is associated with definiteness and functions as a determiner, whereas the postnominal indexing is adverbial and does not display a definiteness restriction. Further research must be carried out to investigate the validity of this with respect to ISL.

As discussed previously in chapter 2, Leeson and Saeed (2012) identify that when quantifiers and numerals are used as determiners, the noun is not normally pluralised. Figure 7.13, taken from the SOI corpus illustrates the sign for BOY in the articulation of the sentence “Some boys think” shown in example 7.2.

Example 7.2 (Leeson and Saeed, 2012: 76, Example 4.8b)

- a) SOME BOY THINK
'some boy(s) think'



Figure 7.13 ISL articulation: SOME BOY THINK, Signs of Ireland Corpus Noeleen (03) Personal Stories (Dublin), Leeson and Saeed, 2012: 76, Example 4.8b

7.6 Analysing ISL Nouns and Pronominal Reference

On investigation of the ISL noun phrase i.e. ISL nouns including operators on the noun, we can report that ISL nouns may be pluralised by reduplication of the noun. They may be modified by adjectives and also colour terms, in which case the adjective typically occurs pre-nominally. When the adjective is a quantifier (for example BIG or SMALL) the quantifier occurs post-nominally in ISL. With regard to determiners, when ISL uses a quantifier or a numeral as a determiner, typically the noun is not pluralised.

In relation to ISL pronominal reference, ISL displays two types of reference to an entity or participant similar to other SLs defined as *anaphoric reference* (applied when a participant or entity is not present) and *deictic* reference (applied when a participant or entity is within the view of the signer). ISL displays a fixed set of locations within the signing space to represent pronouns. ISL pronouns are marked for person and also for number. ISL pronouns are also marked for possession. ISL makes use of the signing space and the visual gestural modality of the language to

allow for role shift or referential shift in which the signer assumes the role of another participant within the discourse. Taking all of this into account we now investigate the four different roles of qualia from the theory of the GL (Pustejovsky, 1995) and investigate the sufficiency of qualia theory in terms of catering for the linguistic phenomena consistent with ISL nominals.

7.7 The Generative Lexicon and Qualia Structure

As discussed in chapter 4, Pustejovsky (1995) defines the Generative Lexicon (GL) as a theory of linguistic semantics which focuses on the distributed nature of compositionality in natural language. Pustejovsky (1991) applied basic Aristotlean principles (Lloyd, 1968) in the development of the generative lexicon (GL) framework and proposed that lexical meaning could best be captured by assuming four levels of representation: Argument Structure, Event Structure, Qualia Structure and Inheritance, with each of these four structures providing a different level of semantic expressiveness and representation needed for a computational theory of lexical semantics. Ambiguity was accounted for by adding more than one word entry into the lexicon. Pustejovsky (1991a: 1), proposed that:

“rather than assuming a fixed set of primitives, let us assume a fixed number of generative devices that can be seen as constructing semantic expressions”.

Qualia structures are defined by Pustejovsky as the modes of explanation associated with a word or phrase. Qualia provide a description of the meaning of lexical items in terms of four roles. Table 7.1, previously shown in section 4.7 and taken from Pustejovsky (1991: 418), provides an outline of these.

Table 7.1 Qualia roles and lexical meaning, Pustejovsky (1991a: 418)

Role	Description
Constitutive	Describing physical properties of an object, i.e. its weight, material as well as parts and components.
Formal	Describing the properties that distinguish an object in a larger domain, i.e. orientation, magnitude, shape and dimensionality.
Telic	Describing the purpose or function of an object.
Agentive	Describing factors involved in the bringing about of an object, i.e. its creator or the causal chain leading to its creation.

7.8 ISL Noun Lexical Entries

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. An example to illustrate the roles provided by Pustejovsky (1991) and re-interpreted by Van Valin (2005) is provided in Example 7.3. Example 7.4 provides an illustration of our proposal for extension to qualia to take into account the Articulatory Structure Level proposed in chapter 4. Example 7.4 provides an extension to example 7.3 (the minimal semantic description described by Van Valin (2005), for the spoken English noun "novel").

Example 7.3 Minimal semantic description for the noun “novel” (Van Valin, 2005)

Novel (y)

Const: **narrative**(y)

Form: **book**(y), **disk**(y),

Telic: **do** (x, [**read** x,y])

Agentive: **artifact**(y), do (x, [**write** (x,y)] & INGR **exist** (y))

Example 7.4

Novel (y)

Const: **narrative**(y)

From: **book**(y [**<TLine><MF><NMF>**]), **disk**(y [**<TLine><MF><NMF>**])

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

Agentive: **artifact**(y), do (x, [**write'** **<TLine><MF><NMF>** (x,y)] & INGR **exist** (y))

Example 7.5 and Example 7.6 illustrate an extension to qualia roles taking into account the Articulatory Structure Level for lexical meaning.

Example 7.5

LADDER (REF y)

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

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

Agentive: **artifact**(REF y), do (x, [**BUILD'** **<TLine><MF><NMF>** (x, REF y)] & INGR **exist** (REF y))

Example 7.6

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)

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 with 3D space. 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, posited in chapter 4 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.

7.9 ISL Pronouns and Possesives and Lexical Entries

As discussed in section 7.4 above, in the general majority of SLs, the space around the signer is used for establishment and maintenance of pronominal (as well as other types of) reference throughout a discourse (Cormier, 2012). Also, the function of *location* in the pronominal sign itself is articulatory in nature and simply part of the sign with no independent morphological meaning (Valli and Lucas, 1995). It is proposed that the ISL pronominal referencing be mapped in 3D signing space in relation to the signer, specific to the fixed spatial locations referred to in Figure 7.2

and Figure 7.3. The signer will use the index finger to point to the fixed locations in 3D space, which are said to refer to specific pronouns in ISL as described in Figure 7.2. In Table 7.2, we provide an illustration of ISL pronouns, the term we use to refer to these within our framework and also a description of the pronoun.

Table 7.2 Mapping ISL pronominals to a fixed spatial position

Pronominal	Lexical Entry Term	Description
I	PRO1	Index pointing to centre of signer's chest.
you	PRO2	Index pointing to neutral space in front of signer.
he/she, him/her	RPRO3	Index pointing to right of signer.
he/she, him/her	LPRO3	Index pointing to left of signer.
You plural, them	ALL-OF-YOU	Index sweeping in curve from left of signer to right
We, all of us here	ALL-OF-US	Index pointing down and making a circular motion anti-clockwise beginning and ending a same point in front of signer's chest.

It is proposed that in terms of lexical entries for pronominal reference we will map the lexical entry terms in Table 7.2 above to (x,y,z) co-ordinates within 3D space similar to Figure 7.2 shown previously. Pronominal reference will be catered for by assuming a predefined set of lexical entry terms, with a predefined location using specific (x,y,z) co-ordinates within 3D space.

7.10 Summary

In this chapter we address RQ3 by providing a definition for the lexical entries for ISL nouns and the layered structure of the clause within the lexicon. We provide an account of ISL nouns and operators that modify the noun. We provide an account of how ISL nouns are referenced within ISL discourse and the various methods used by signer's to communicate information pertaining to these highly complex linguistic units. We provide an account of both anaphoric and deictic reference and also the underpinnings of pronominal reference in ISL. We provide a methodology in terms of mapping pronominal reference to specific (x,y,z) locations within 3D

space in relation to the signer. We also look to GL qualia theory (Pustejovsky, 1995) and we posit that to accurately represent ISL nouns in computational linguistic terms and within the ISL lexicon, we must extend the theory of qualia to cater for the linguistic phenomena presented by ISL nouns. We must extend the definition of lexical items to cater for ISL nouns, catering for the visual gestural modality of the language. We posit that we must extend *constitutive*, *formal*, *agentive* and *telic* roles (Pustejovsky, 1995) to allow qualia theory to cater for the linguistic phenomena pertinent to nouns within ISL. We implement a parameter termed REF_{LOC} which extends itself as a placeholder to the (x,y,z) co-ordinates of the location within 3D space that the noun exists and can be referenced. We refer to the Articulatory Structure Level for lexical meaning, an extension to Pustejovsky (1991) and the theory of the GL to cater for the various linguistic phenomena consistent with ISL, a visual gestural language in terms of lexical entries. We use our Articulatory Structure Level to leverage our development of a rich logical structure for ISL noun entries. We articulate the linking system from the lexicon to include extended lexicon representation into visual syntax for ISL nouns. With regard to spoken language linguistics, we mentioned previously in section 4.9 that gesture and non-verbal communication are an important part of face-to-face spoken language communication (McNeill, 1992; Ní Chasaide and Gobl, 1990). It is important to note at this juncture that the utilisation of Articulatory Structure Level and the extension to the theory of qualia for ISL nouns may also have implications with regard to spoken language linguistics where the REF_{LOC} parameter may have the potential to provide a locus within 3D space with regard to gesture and non-verbal communication.

8. The Layered Structure of the Clause of ISL

8.1 Introduction

This chapter addresses RQ 3 by providing an account of the Layered Structure of the Clause (LSC) for ISL while also incorporating an account of the Layered Structure of the Noun Phrase (LSNP) for ISL. We illustrate an account for the LSC and LSNP by provision of both an operator and constituent projection within our functional model of grammar, RRG, the theoretical framework utilised within this body of research. We provide evidence to support RQ3 and our hypothesis in relation to lexical entries for ISL verbs, ISL classifiers and ISL nouns. We demonstrate that our linguistically motivated computational framework model has applicability to the LSC and also to the LSNP by illustrating these in terms of RRG constituent projections and operator projections for simple ISL sentences.

8.2 The Layered Structure of the Clause for ISL Verbs

This sections provides RRG constituent and operator projection diagrams for ISL verbs based on tripartite verb categories. We provide an account for plain verbs and agreement verbs by providing an analysis of the ISL sentence together with the transitivity, Aktionsart class and verb class. We also provide the RRG + Sign_A logical structure for the ISL sentence using our proposed Sign_A framework. Finally we provide an account of each sentence in terms of RRG constituent and operator projections.

8.2.1 LSC for ISL Plain Verbs

8.2.1.1 ISL Intransitive Plain Verb Constituent and Operator Projection

In Table 8.1 following, we provide information pertaining to the sentence ARRIVE HOTEL. In terms of the ISL plain verb ARRIVE we provide transitivity, Aktionsart class and verb class. We also provide an extended RRG logical structure for the ISL sentence using our proposed Sign_A framework.

ARRIVE HOTEL

‘(I) arrived at the hotel’

Based on Example 5.6, SOI Corpus Mary (30) Personal Stories (Cork)

ISL Verb	Verb class	Transitivity	Akionsart class
ARRIVE	plain	intransitive	achievement
RRG + Sign_A Logical Structure			
INGR ARRIVE ’ <TLine><MF><NMF> (1sg, HOTEL)			

Table 8.1 Analysis of ISL intransitive plain verb ARRIVE.

Figure 8.1 provides an illustration of both the MF and NMF parameters used to communicate this sentence. Time (t) representing the overall timeline with each parameter within the articulation having an event duration time (e) associated with it. This event duration allows the various MF and NMF parameters to ‘play out’ for a designated amount of time and in sequence in relation to the overall timeline (t) in order to communicate a coherent and comprehensible utterance in ISL. Figure 8.2 provides an RRG constituent and operator projection. The plain verb ARRIVE is marked for aspect in the operator projection. Due to the fact that the entity (the signer) has been identified earlier, this entity will exist within the discourse common ground.

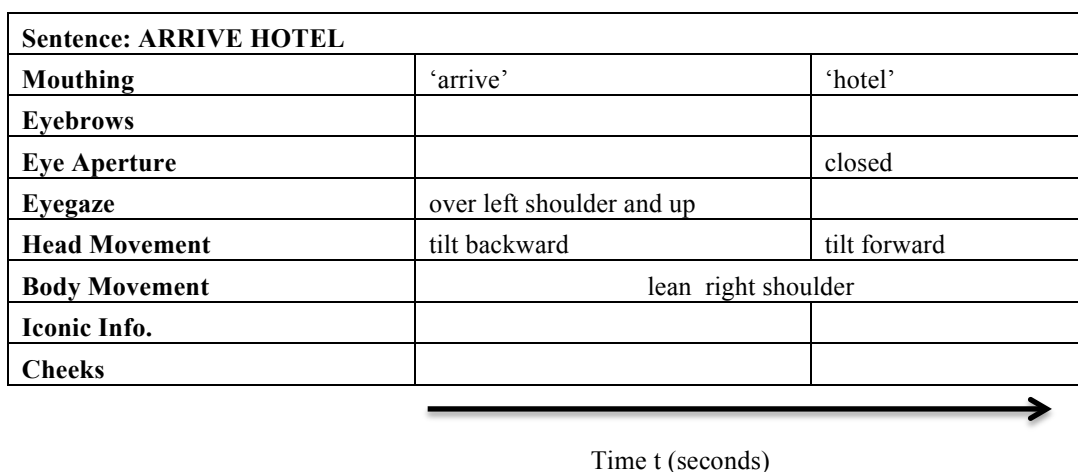


Figure 8.1 ISL plain verb ARRIVE NMF parameters over time

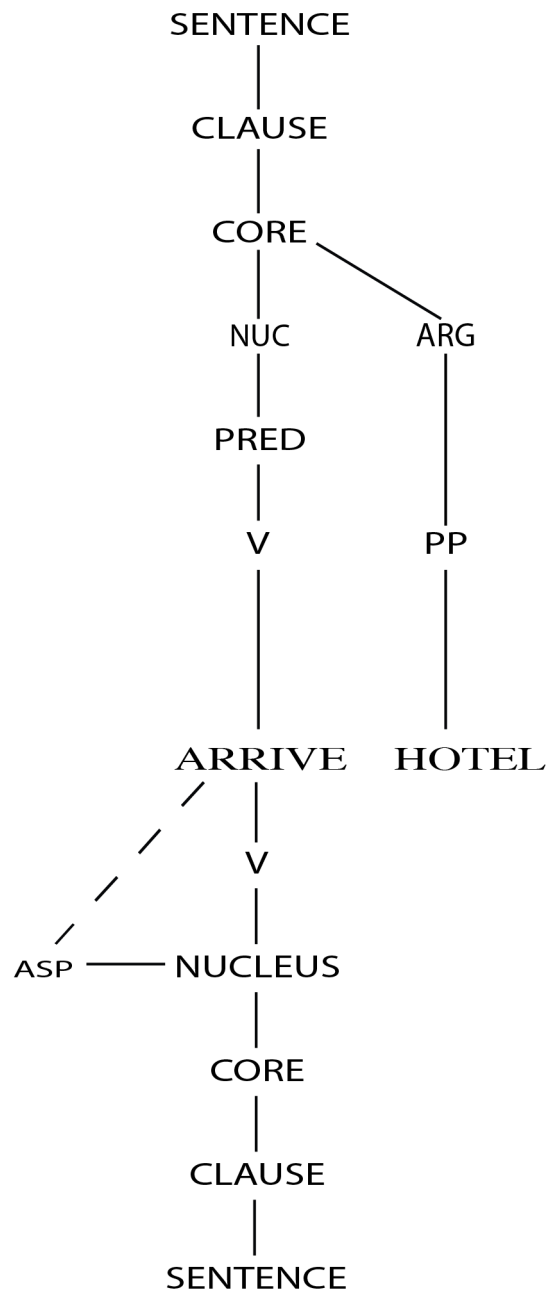


Figure 8.2 RRG constituent and operator projection ISL plain verb ARRIVE

8.2.1.2 ISL Transitive Plain Verb Constituent and Operator Projection

Table 8.2 provides information pertaining to the ISL plain verb LIKE. In terms of the ISL plain verb LIKE we provide transitivity, Aktionsart class and verb class. We also provide an extended RRG logical structure for the ISL sentence using our proposed Sign_A framework used in the articulation of the sentence:

REAL LIKE MY JOB

‘I really love my job’

SOI Corpus Noeleen (03) Personal Stories (Dublin)

Table 8.2 Analysis of ISL transitive plain verb LIKE

ISL Verb	Tripartite verb class	Transitivity	Aktionsart class
LIKE	plain	transitive	state
RRG+ Sign_A Logical Structure			
LIKE' <TLine><MF><NMF> (1sg, JOB)			

Sentence: REAL LIKE MY JOB			
Mouthing	‘love’	‘my’	‘job’
Eyebrows			
Eye Aperture	normal		
Eyegaze	Turn +sl	straight ahead	
Head Movement	Turn +sl	turn +sl	
Body Movement			
Iconic Information			
Cheeks			


 Time t (seconds)

Figure 8.3 ISL plain verb LIKE NMF parameters over time

Figure 8.3 provides an illustration of both the MF and NMF parameters used to communicate this sentence. Time (t) representing the overall timeline with each parameter within the articulation having an event duration time (e) associated with it. This event duration allows the various MF and NMF parameters to ‘play out’ for a designated amount of time and in sequence in relation to the overall timeline (t) in order to communicate a coherent and comprehensible utterance in ISL. Figure 8.4 provides an RRG constituent and operator projection. The transitive verb LIKE is marked for aspect in the operator projection.

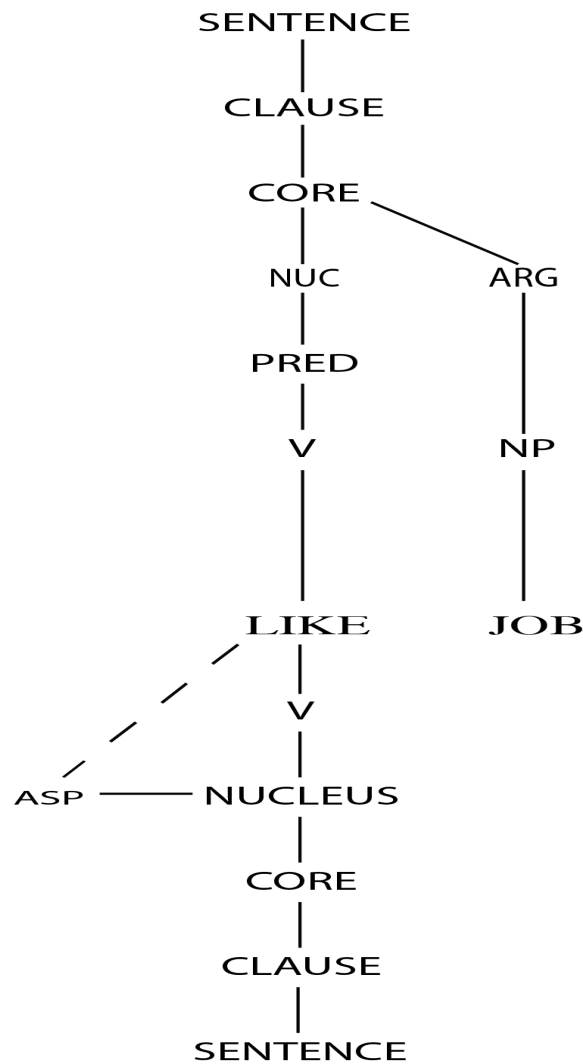


Figure 8.4 RRG constituent and operator projection ISL plain verb LIKE

8.2.1.3 ISL Ditransitive Plain Verb Constituent and Operator Projection

In Table 8.3 In terms of the ISL ditransitive plain verb MAKE we provide transitivity, Aktionsart class and ISL verb class. We also provide an extended RRG logical structure for the ISL sentence using our proposed Sign_A framework used in the articulation of the sentence:

INDEX+c MAKE DINNER FOR SIGN NAME (PAT OSHEA)

‘I made dinner for Pat O’Shea ’

SOI Corpus Alice (29) Personal Stories (Cork)

Table 8.3 Analysis of ISL ditransitive plain verb MAKE

ISL Verb	Tripartite verb class	Transitivity	Aktionsart class
MAKE	plain	ditransitive	accomplishment
RRG + Sign_A Logical Structure			
BECOME cook' <TLine><MF><NMF> (1sg, DINNER) & be_at (DINNER, SIGN NAME)			

Sentence: I made dinner for Pat O'Shea					
Mouthing	'I'	'made'	'dinner' (seconds)	'for'	'Pat O'Shea'
Eyebrows	raised	raised	furrowed		
Eye Aperture			squint		squint
Eyegaze	straight ahead	shoulder left	down	straight ahead	down
Head Movement	tilt forward	headnod	headnod	headnod	headnod
Body Movement	lean forward	shoulder hunched	shoulder hunched	lean shoulder left	shoulder hunched
Iconic Info.					
Cheeks					



Figure 8.5 ISL plain verb MAKE NMF parameters over time

Figure 8.5 provides an illustration of both the MF and NMF parameters used in the articulation of this sentence. Time (t) represents the overall timeline, with each parameter within the articulation having an event duration time (e) associated with it. This event duration allows the various MF and NMF parameters to ‘play out’ for a designated amount of time and in sequence in relation to the overall timeline (t), in order to communicate a coherent and comprehensible utterance in ISL. Figure 8.6 provides an illustration of the RRG constituent and operator projection. The ditransitive verb MAKE is marked for aspect in the operator projection.

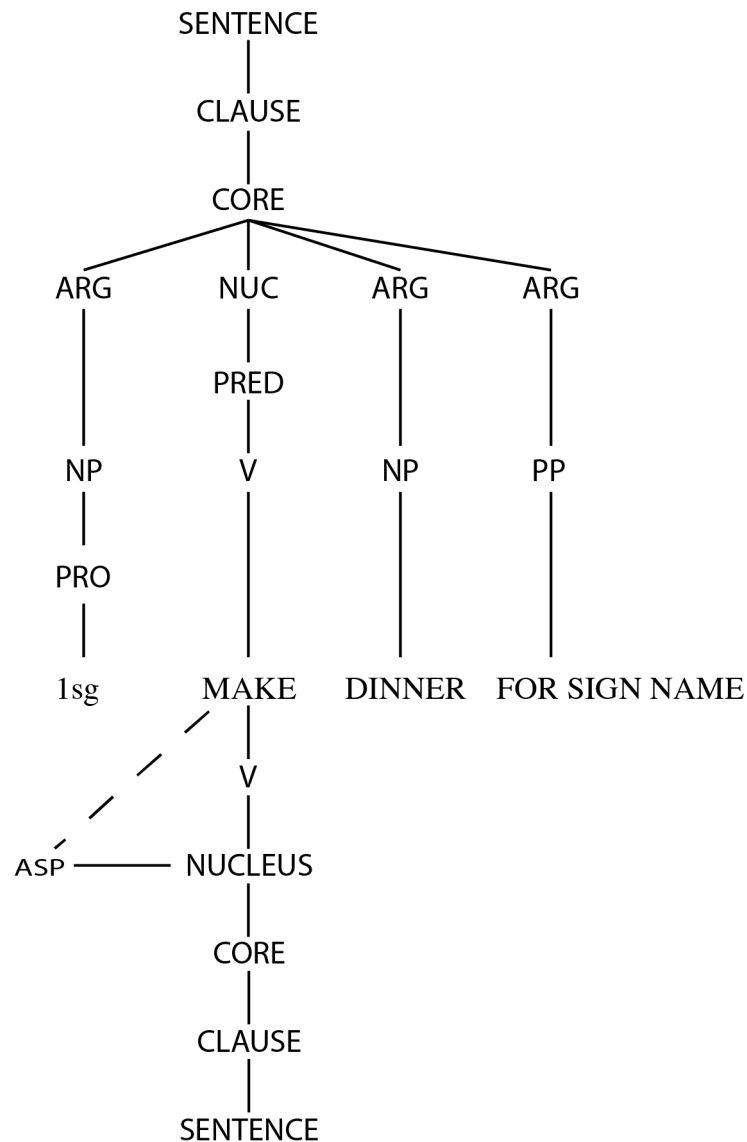


Figure 8.6 RRG constituent and operator projection ISL plain verb MAKE

8.2.2 The Layered Structure of the Clause for ISL Person Agreement Verbs

8.2.2.1 Single Agreement Verb Constituent and Operator Projection

In Table 8.4 we illustrate information pertaining to the the ISL verb TELL-ME. In terms of the ISL agreement verb TELL-ME we provide transitivity, Aktionsart class and verb class. We also provide an extended RRG logical structure for the ISL sentence using our proposed Sign_A framework. In Table 8.5 we provide an illustration of the MF computational parameters defined previously in our proposed Sign_A framework. Table 8.5 provides an illustration of the MF parameters used in the articulation of the sentence:

GUIDE TELL-ME

‘The tour guide told me’

SOI Corpus Mary (33) Personal Stories (Galway)

Table 8.4 Analysis of ISL single agreement verb TELL-ME

ISL Verb	Verb Class	Transitivity	Aktionsart Class
TELL-ME	Agreement (single)	Transitive	Activity
RRG + Sign_A Logical Structure			
do' (GUIDE, [TELL-ME' ^b <TLine><MF><NMF> (GUIDE, ^b 1sg)])			

Table 8.5 ISL TELL-ME Manual Feature Parameter Representation

ISL Manual Feature Parameter	ISL Manual Feature Representation
Handshape <HS>	Index up
Location <LOC>	^b Locus: reference to direct object of conversation
Movement <MOV>	Movement from mouth toward signer's chest representing first person singular 'me'
Orientation <ORI>	Palm facing towards signer

Figure 8.6 provides an illustration of the RRG constituent and operator projection. The transitive person agreement verb TELL-ME is marked for aspect in the operator projection.

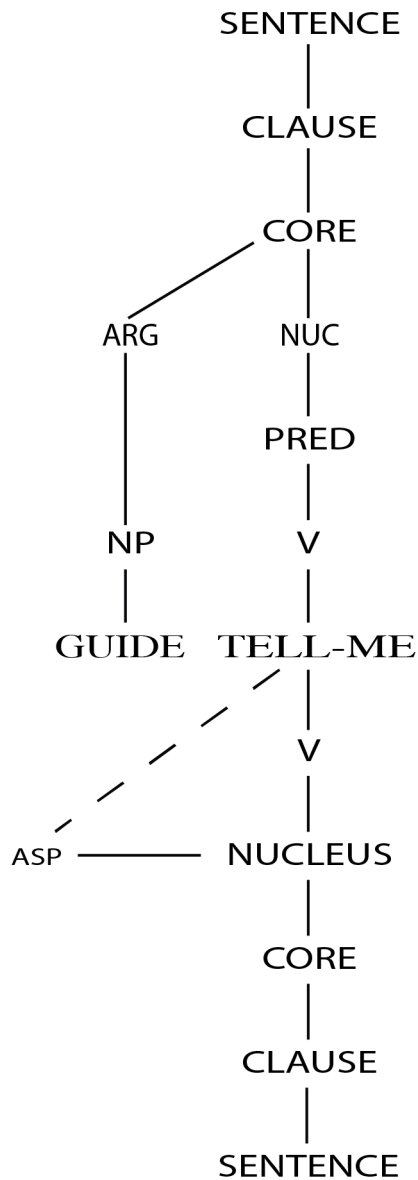


Figure 8.7 RRG constituent and operator projection ISL single agreement verb TELL-ME

8.2.2.2 Double Agreement Verb Constituent and Operator Projection

In Table 8.6 we illustrate information pertaining to the ISL verb ACCUSE. In terms of the ISL double agreement verb ACCUSE we provide transitivity, Aktionsart class and verb class. We also provide an extended RRG logical structure for the ISL sentence using our proposed Sign_A framework. In Table 8.7 we provide an

illustration of the MF computational parameters defined in our proposed Sign_A framework illustrating the MF parameters used in the articulation of the sentence:

c+ACCUSE+f

‘I blame you’

McDonnell (1996: 160, Example 5.62)

Table 8.6 Analysis of ISL double agreement verb ACCUSE

ISL Verb	Verb Class	Transitivity	Aktionsart Class
ACCUSE	Agreement (double)	Transitive	Activity
RRG + Sign_A Logical Structure			
do'(c, [^aACCUSE'^b <TLine><MF> <NMF> (^a1sg, ^b2sg)])			

Table 8.7 ISL ACCUSE Manual Feature Parameter Representation

ISL Manual Feature Parameter	ISL Manual Feature Representation
Handshape <HS>	Both hands[24]
Location <LOC>	(^a body chest) (^b pronominal reference 2sg‘you’). Location also marks for source and goal of subject and object.
Movement <MOV>	From location a to point b
Orientation <ORI>	Palm facing down with fingertips forward

Figure 8.8 provides the RRG constituent and operator projection. The transitive double agreement verb ACCUSE is marked for aspect in the operator projection.

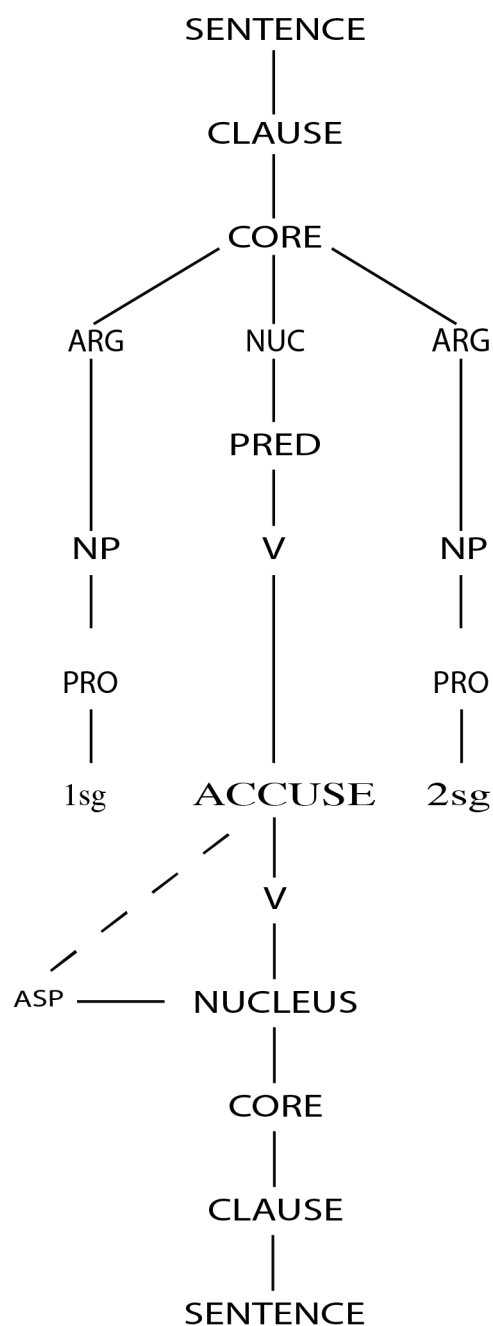


Figure 8.8 RRG constituent and operator projection ISL double person agreement verb ACCUSE

8.2.2.3 Backward Agreement Verb Constituent and Operator Projection

In Table 8.8 we illustrate information pertaining to the sentence:

c+CHOOSE+f

‘I chose (something)’

SOI Corpus Kevin (17) Personal Stories (Dublin)

In terms of the ISL backward agreement verb CHOOSE we provide transitivity, Aktionsart class and verb class. We also provide an extended RRG logical structure for the ISL sentence using our proposed Sign_A framework. In Table 8.9 we provide an illustration of the MF computational parameters defined in our proposed Sign_A framework, illustrating the MF parameters used in the communication of the sentence.

Table 8.8 Analysis of ISL backward agreement verb CHOOSE

ISL Verb	Verb Class	Transitivity	Aktionsart Class
CHOOSE	Agreement (backward)	Transitive	Achievement
RRG + Sign_A Logical Structure			
INGR ^b CHOOSE' ^a <TLine><MF> <NMF> (^a 1sg, ^b something)			

Table 8.9 ISL CHOOSE Manual Feature Parameter Representation

ISL Manual Feature Parameter	ISL Manual Feature Representation
Handshape <HS>	Dominant hand is in handshape [7] depicting the fingers picking up something.
Location <LOC>	(^a body chest) (^b locus for the item the signer is choosing located within 3D space, this is catered for using the signing space allocation map for the Sign_A framework provided in Figure 4.12). The REF _{LOC} parameter, defined previously in section 7.8, will provide the locus for the item being chosen. Location also marks for goal and source of object and subject.
Movement <MOV>	From location b to point a
Orientation <ORI>	Palm facing down with fingertips gripping representing the signer is holding something.

Figure 8.9 provides the RRG constituent and operator projection for our sentence. The transitive backward agreement verb CHOOSE is marked for aspect in the operator projection.

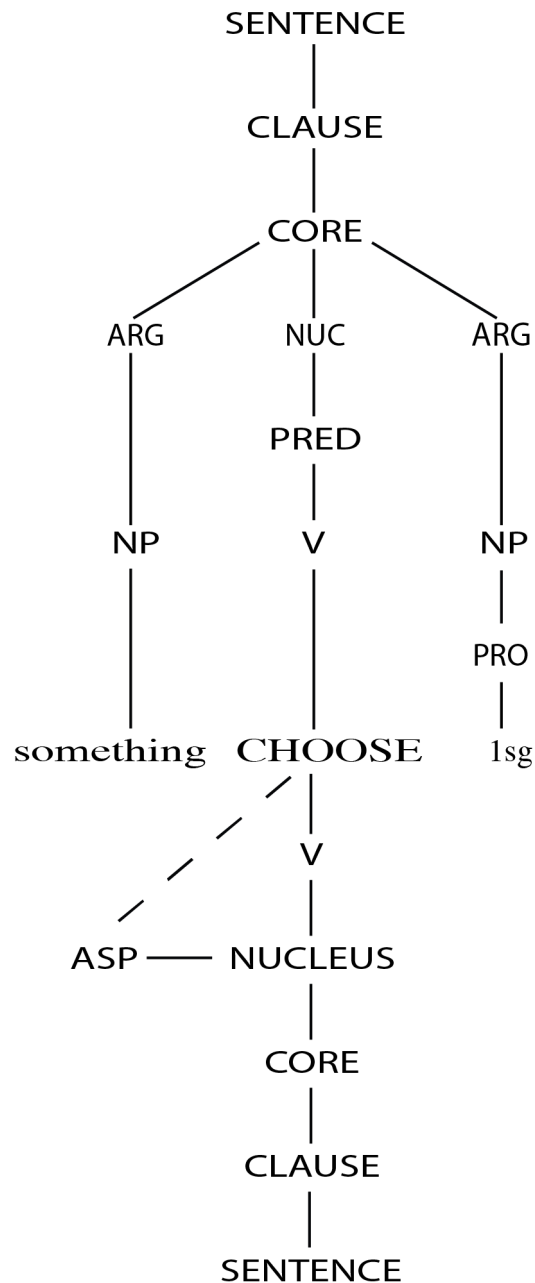


Figure 8.9 RRG constituent and operator projection ISL backward agreement verb CHOOSE

8.2.2.4 Reciprocal Agreement Constituent and Operator Projection

In Table 8.10 In terms of the ISL reciprocal agreement verb DISCUSS we provide transitivity, Aktionsart class and verb class. We also provide an extended RRG logical structure for the ISL sentence using our proposed Sign_A framework. In

Table 8.11 we provide an illustration of the MF computational parameters defined in our proposed Sign_A framework, illustrating the MF parameters used in the communication of the ISL sentence:

c+DISCUSS+f

f+DISCUSS+c

“We discussed the issue”

SOI Corpus Annie (26) Personal Stories (Wexford)

Table 8.10 Analysis of ISL reciprocal agreement verb DISCUSS

ISL Verb	Verb Class	Transitivity	Aktionsart Class
DISCUSS	Agreement (reciprocal)	Transitive	Accomplishment
RRG + Sign_A Logical Structure			
do' (1sg and 2sg , [^a DISCUSS' ^b <TLine><MF> <LOC> <NMF> (^a 1sg and 2sg, ^b 2sg)])			

Table 8.11 ISL DISCUSS Manual Feature Parameter Representation

ISL Manual Feature Parameter	ISL Manual Feature Representation
Handshape <HS>	Use of two hands representing iterative nature.
Location <LOC>	plural form we represented by movement between neutral space toward signer in an iterative fashion using two hands //shows iterative nature.
Movement <MOV>	First person plural form ‘we’ is represented by movement from neutral space toward signer using two hands.
Orientation <ORI>	Palm facing upwards and tilted towards the signer’s face.

Figure 8.10 provides the RRG constituent and operator projection for the ISL reciprocal verb. The reciprocal agreement verb DISCUSS is marked for aspect in the operator projection.

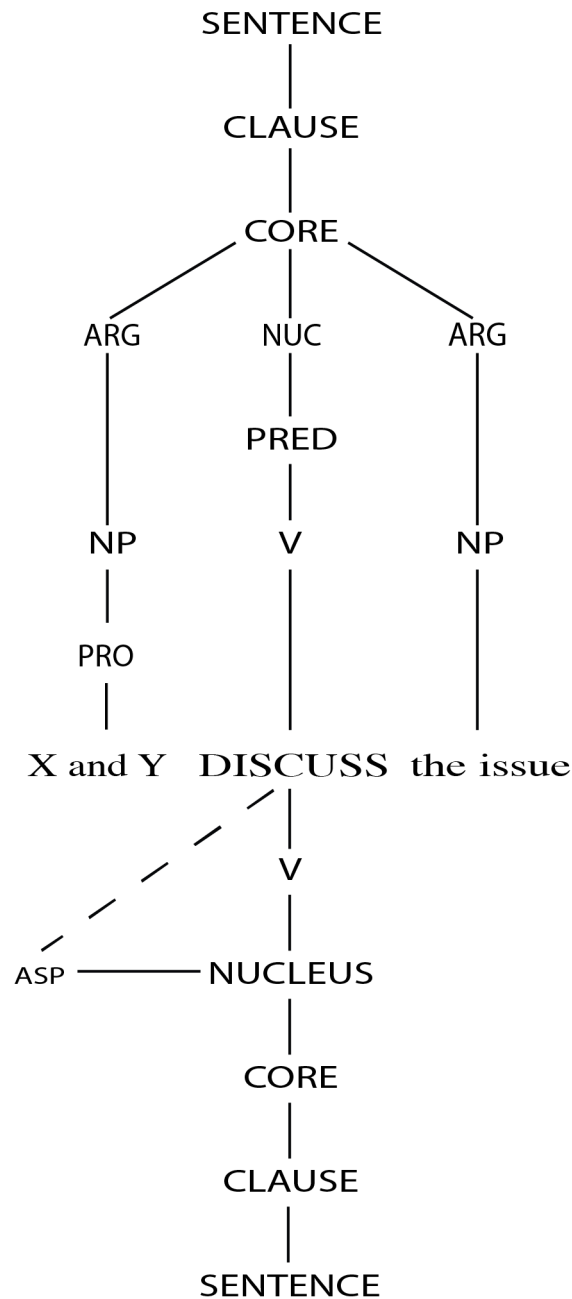


Figure 8.10 RRG constituent and operator projection ISL reciprocal agreement verb DISCUSS

8.2.3 The Layered Structure of the Clause for ISL Locative Agreement Verbs

8.2.3.1 Locative Agreement Constituent and Operator Projection

In Table 8.12 we illustrate information pertaining to the ISL verb KNOCK. In terms of the ISL locative agreement verb KNOCK we provide transitivity, Aktionsart class and verb class. We also provide an extended RRG logical structure for the ISL

sentence using our proposed Sign_A framework. In Table 8.13 we provide an illustration of the MF computational parameters defined in our proposed Sign_A framework, illustrating the MF parameters used in the communication of the sentence:

KNOCK++++

‘I was banging down the door’

SEML ^aKNOCK^b <TLine><MF><NMF> ((^a1sg, ^bDOOR)

SOI Corpus Catharine (31) Personal Stories (Cork)

Table 8.12 Analysis of ISL spatial agreement verb KNOCK

ISL Verb	Verb Class	Transitivity	Aktionsart Class
KNOCK	Agreement (spatial)	Intransitive	Semelfactive
RRG + Sign_A Logical Structure			
SEML ^a KNOCK ^b <TLine><MF><NMF> ((^a 1sg, ^b DOOR)			

Table 8.13 ISL KNOCK Manual Feature Parameter Representation

ISL Manual Feature Parameter	ISL Manual Feature Representation
Handshape <HS>	Use of dominant hand in handshape [1] representing the hand in a fist used to represent the signer knocking on a door.
Location <LOC>	The hand is outstretched at eye level. The ^a locus represents the signer and is represented by the hand. The ^b locus refers to the entity the signer is knocking upon, which is the door.
Movement <MOV>	First person plural form ‘we’ is represented by movement from neutral space toward signer using two hands.
Orientation <ORI>	Palm with hand in fist facing towards door facing.

Figure 8.11 provides the RRG constituent and operator projection. The locative agreement verb KNOCK is marked for aspect in the operator projection. This is an example of argument ellipsis, where the x and y arguments are not overtly realised and therefore elided. It is assumed that these entities have been identified earlier exist in discourse context and are salient in this example.

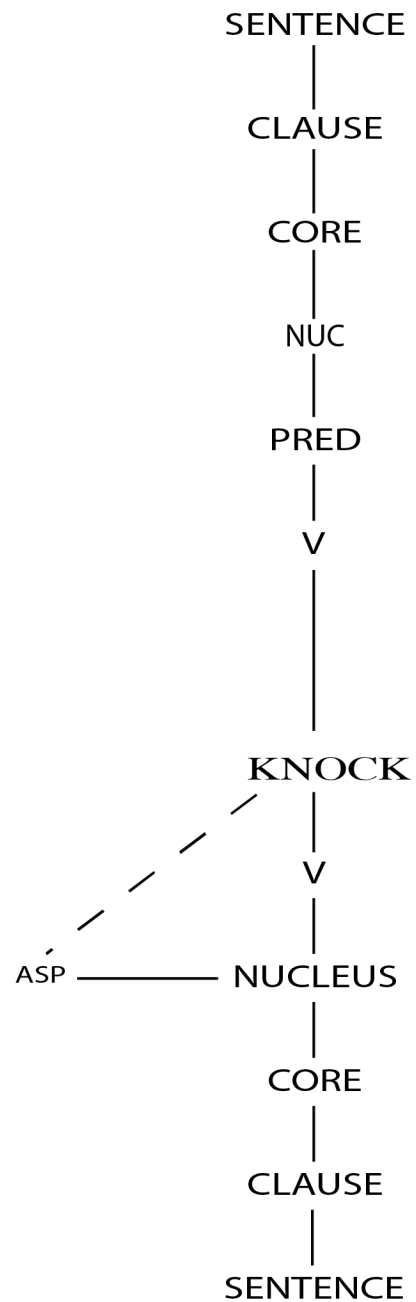


Figure 8.11 RRG constituent and operator projection ISL spatial agreement verb KNOCK

8.2.3.2 Body Anchored Locative Agreement Constituent and Operator Projection

In Table 8.14 we illustrate information pertaining to the ISL verb SLAP. In terms of the ISL body anchored agreement verb SLAP we provide transitivity, Aktionsart class and verb class. We also provide an extended RRG logical structure for the ISL

sentence using our proposed Sign_A framework. In Table 8.11 we provide an illustration of the MF computational parameters defined in our proposed Sign_A framework, illustrating the MF parameters used in the communication of the sentence:

BOY SLAP+FACE c

‘The boy slapped me on the face’

McDonnell (1996: 160, Example 5.62)

Table 8.14 Analysis of ISL body anchored agreement verb SLAP

ISL Verb	Verb Class	Transitivity	Aktionsart Class
SLAP	Agreement (body anchored)	Ditransitive	Achievement
RRG + Sign_A Logical Structure			
on(^c FACE,[^a SLAP' ^b <TLine><MF><NMF> (^a 3sg, ^b 1sg)])			

Table 8.15 ISL SLAP Manual Feature Parameter Representation

ISL Manual Feature Parameter	ISL Manual Feature Representation
Handshape <HS>	Use of dominant hand in handshape [16] representing the hand used to slap.
Location <LOC>	(^a locus pronominal reference/source or subject) (^b locus movement in direction of signer marking the object, which is the signer in this instance. (^c face is the body anchored location or goal).
Movement <MOV>	Movement from ^a locus towards ^b locus (the signer) and also towards ^c locus (the signer's face) showing direction.
Orientation <ORI>	Palm facing upwards and tilted towards the signer's face.

Figure 8.12 provides the RRG constituent and operator projection for the sentence. The body anchored locative agreement verb SLAP is marked for aspect in the operator projection. In relation to this body anchored agreement verb, similar to RRG logical structures for English, the *slap* occurs *on* the location of *the face*. The PP expresses the location of the event of slapping and therefore, *on* is identified as the highest predicate in the logical structure and it takes *the face* and the logical structure for *slap* as its two arguments. The ^clocus is a body anchored location and

therefore it is associated with the ^blocus and occurs *on* the ^blocus in this case the face of the person signing.

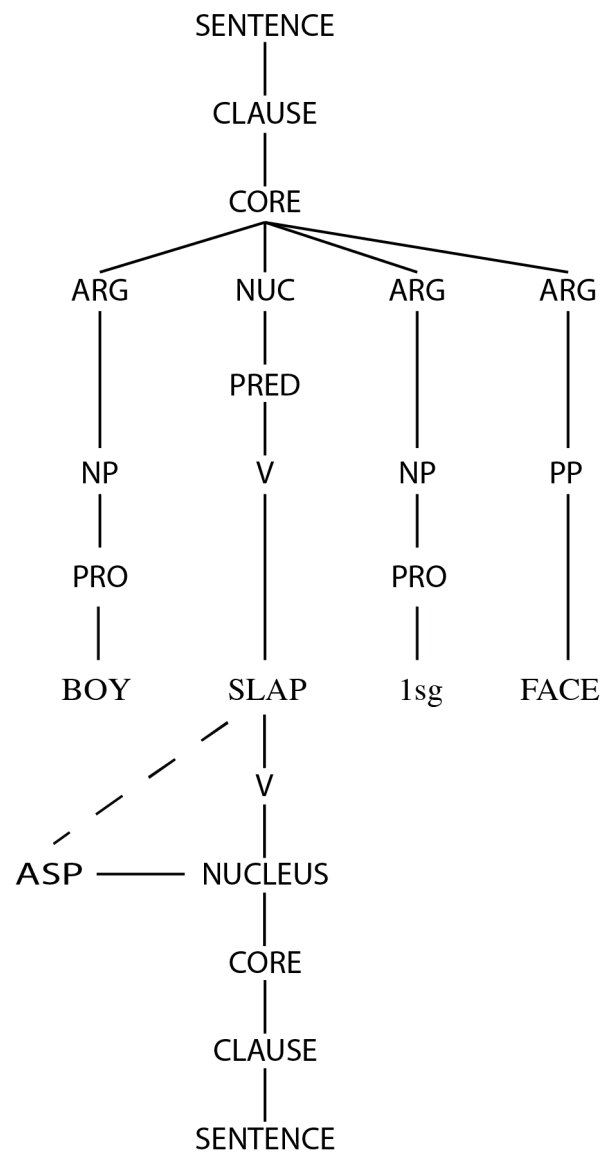


Figure 8.12 RRG constituent and operator projection ISL body anchored agreement verb SLAP

8.3 The Layered Structure of the Clause for ISL Whole Entity Classifiers

8.3.1 The Layered Structure of the Clause for ISL Person Two Legs Classifier

In Table 8.16 we illustrate information pertaining to the sentence:

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’

SOI Corpus Orla (04) Personal Stories (Dublin)

In terms of this ISL Whole Entity Classifier we provide transitivity, Aktionsart class and classifier type. We also provide an extended RRG + Sign_A logical structure for the ISL sentence utilising our proposed Sign_A framework. As discussed previously in chapter 6, the classifier handshape [47], in Figure 6.2, 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 ^blocus (^bthe 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.

Note: In this example, similar to other examples following, we deal with simultaneous signed constructions. In the case we pass in information pertaining to the dominant hand parameters first, followed by information pertaining to the non dominant hand. We separate this information using a full stop ‘.’.

Table 8.16 Analysis of ISL sentence person two legs classifier

Classifier Shape	Transitivity	Aktionsart Class	Classifier Type
Classifier [47] V bent fingers	Intransitive	Activity	Whole Entity +animate two legs
RRG + Sign A Logical Structure			
^{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. orientation-sr+hi ^b)			

Figure 8.13 provides the RRG constituent and operator projections for the sentence. The Whole Entity Classifier is marked for aspect in the operator projection.

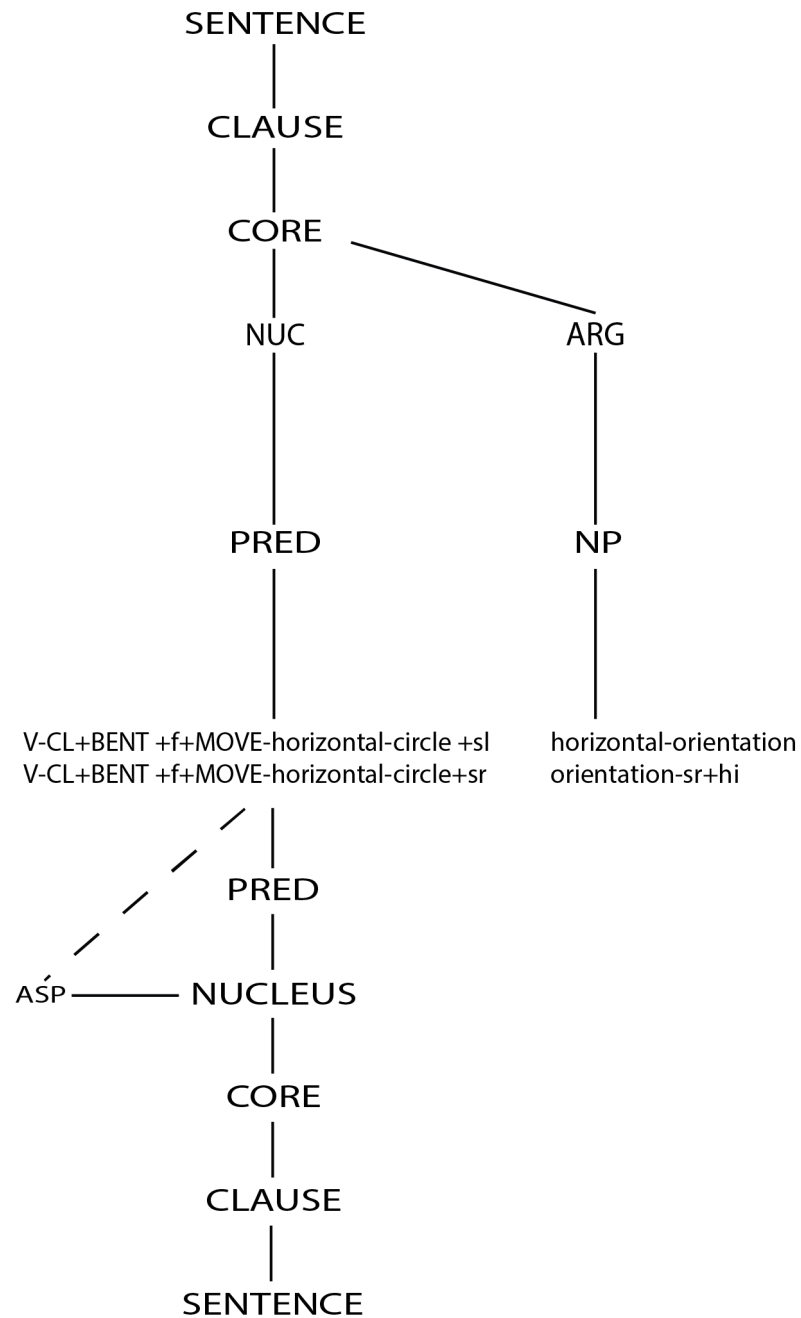


Figure 8.13 RRG constituent and operator projection ISL person two legs classifier

8.3.2 The Layered Structure of the Clause for ISL Person Index Up Classifier

In Table 8.17 we illustrate information pertaining to the sentence:

dh: I SEE TWO GIRL Index-CL+MOVE-towards-fl+EXIST+orientation-sl

nh: Index-CL+MOVE-towards-c+EXIST+orientation-sr

‘I saw two girls approach each other’

This sentence provides us with a nexus juncture relation in relation to RRG, wherein the sentence displays two cores with a shared noun phrase (NP) argument. Table 8.17 provides information pertaining to the sentence to include transitivity, Aktionsart class and verb class. In terms of this ISL Whole Entity Classifier *approach* we also provide the classifier type. Table 8.17 also provides the extended RRG + Sign_A logical structure for the ISL sentence utilising our proposed Sign_A framework.

Table 8.17 Analysis of ISL sentence person index up classifier

Classifier Shape	Transitivity	Aktionsart Class	Verb Class
-	Transitive	State	Plain verb
Whole Entity +animate index up	Transitive	Activity	Classifier
RRG + Sign_A Logical Structure			
SEE' <TLine><MF><NMF> (1sg, ^x GIRL.pl)			
do' (^{xa} index-CL. index-CL, [^{ab} MOVE-towards-c.MOVE-towards- ^{c'} <Tline><MF><NMF> (^{xa} index-CL. index-CL, ^b EXIST+c+orientation- sl.EXIST+c+orientation-sr)])			

As discussed previously in chapter 6, the ^xlocus illustrated in our extended logical structure for the verb SEE, is the undergoer of the verb SEE. This ^xlocus is associated with the girls or the undergoer (^xGIRL.pl), which is articulated in a lexical sign for girl, with the one hand in the [24] shape, from Figure 6.2, with the palm facing towards signer's face and index finger moving down from cheek bone to chin.

Within the extended logical structure, the classifier handshape [24], from Figure 6.2, (which is categorised in ISL as an +animate index up whole entity classifier and used in this case to represent a human person) represents the ^{xa}index-CL.index-CL entry in the LS . The *x* in this case is used to associate the ^{xa}index-CL.index-CL classifier in this logical structure with the undergoer of the previous logical

structure for *see* (^xGIRL.pl). This ^x denotes that the classifier now depicts and is a reference to the girls/undergoer/object/entity. The ^a in the ^{xa}index-CL.index-CL LS entry now representing the girls in this phrase.

This classifier handshape argument represents the theme or subject of the activity and is used to denote two animate entities in space moving towards the ^blocus location, which is actually towards one another in this example. In this case the two upward facing index fingers of the left and right hand move with palms facing one another from the location to the signer's right and left side respectively to stop short of contact in front of the signer, with the ^blocus referring to this.

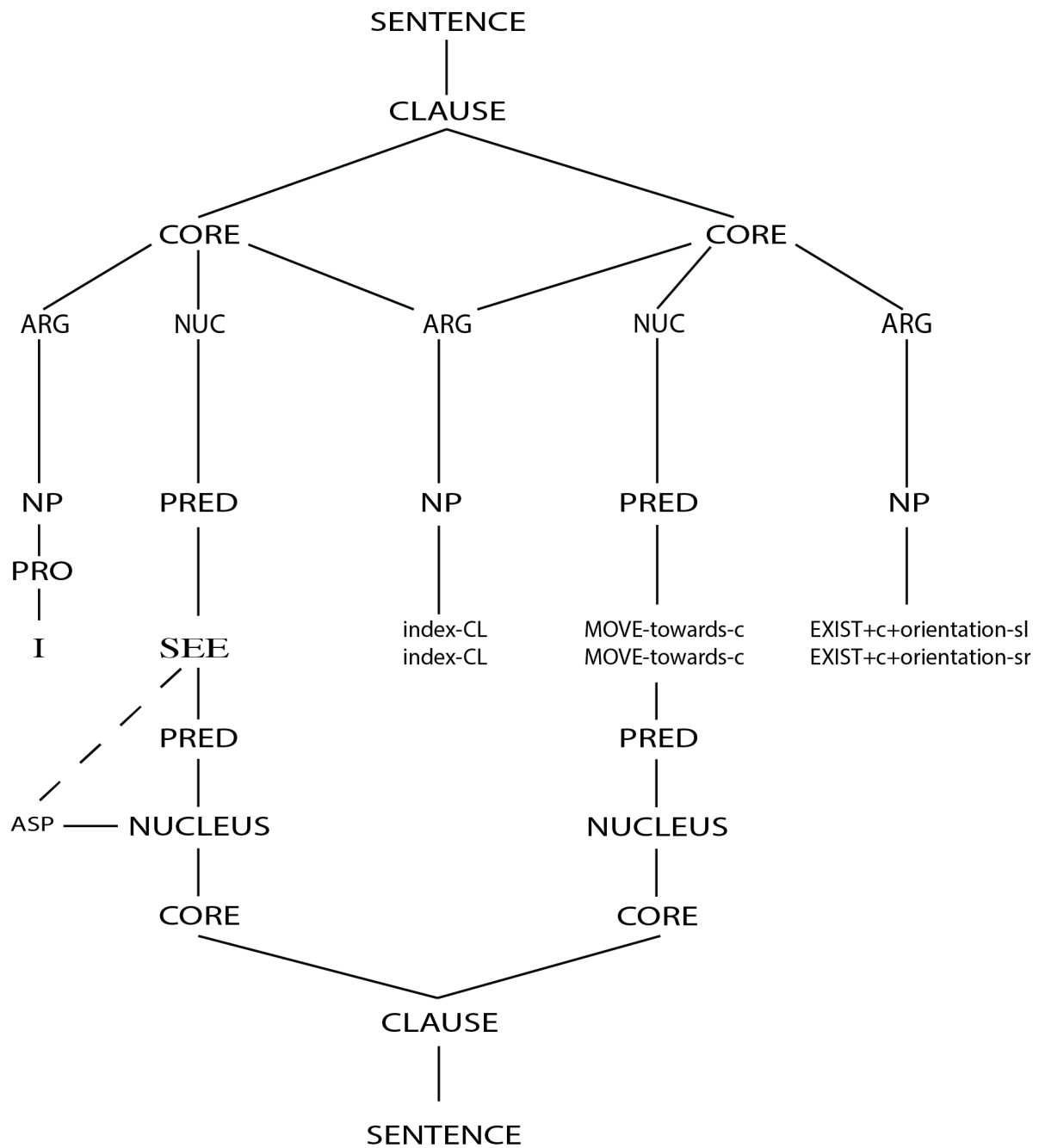


Figure 8.14 RRG constituent and operator projection person index up classifier

8.3.3 The Layered Structure of the Clause for ISL Inanimate Entity Classifier

In Table 8.18 we illustrate the ISL structure for the ISL sentence:

dh: Vehicle-CL+MOVE+sl+contact left hand

nh: Vehicle-CL+EXIST+base of palm -----

‘The jeep crashed into the back of the car’.

The table illustrates information pertaining to the ISL structure to include transitivity, Aktionsart class and verb class. In terms of the ISL classifier construction we also provide the classifier type. As discussed previously, in chapter 6, this classifier handshape argument represents the theme or subject of the activity verb drive and is used to denote the driving or crashing into a separate classifier, namely the car. Semantic change in terms of the *jeep* is represented by a change of handshape from the [18] handshape, in Figure 6.2, to the [4] handshape, in Figure 6.2. The jeep is represented by the dominant hand and the car by the non-dominant hand. Note that both hands are used in the gloss. One representing the jeep and the other representing the car.

Table 8.18 also provides the extended RRG + Sign_A logical structure for the ISL sentence utilising Articulatory Structure Level and our proposed Sign_A framework.

Table 8.18 Analysis of ISL sentence ISL vehicle classifier

Verb Class	Transitivity	Aktionsart Class	Classifier Type
Classifier	Transitive	Activity	Whole Entity -animate vehicle
RRG + Sign_A Logical Structure			
do' (^a vehicle-CL, [^a MOVE+sl+contact left hand ^{br} <TLine><MF><NMF> (^{xa} vehicle CL, ^b vehicle CL+EXIST+base of palm))			

dh:Vehicle-CL+MOVE+sl+contact left hand

nh:Vehicle-CL+EXIST+base of palm -----

‘The jeep crashed into the car’.

Figure 8.15 provides the RRG constituent and operator projections for the ISL sentence above.

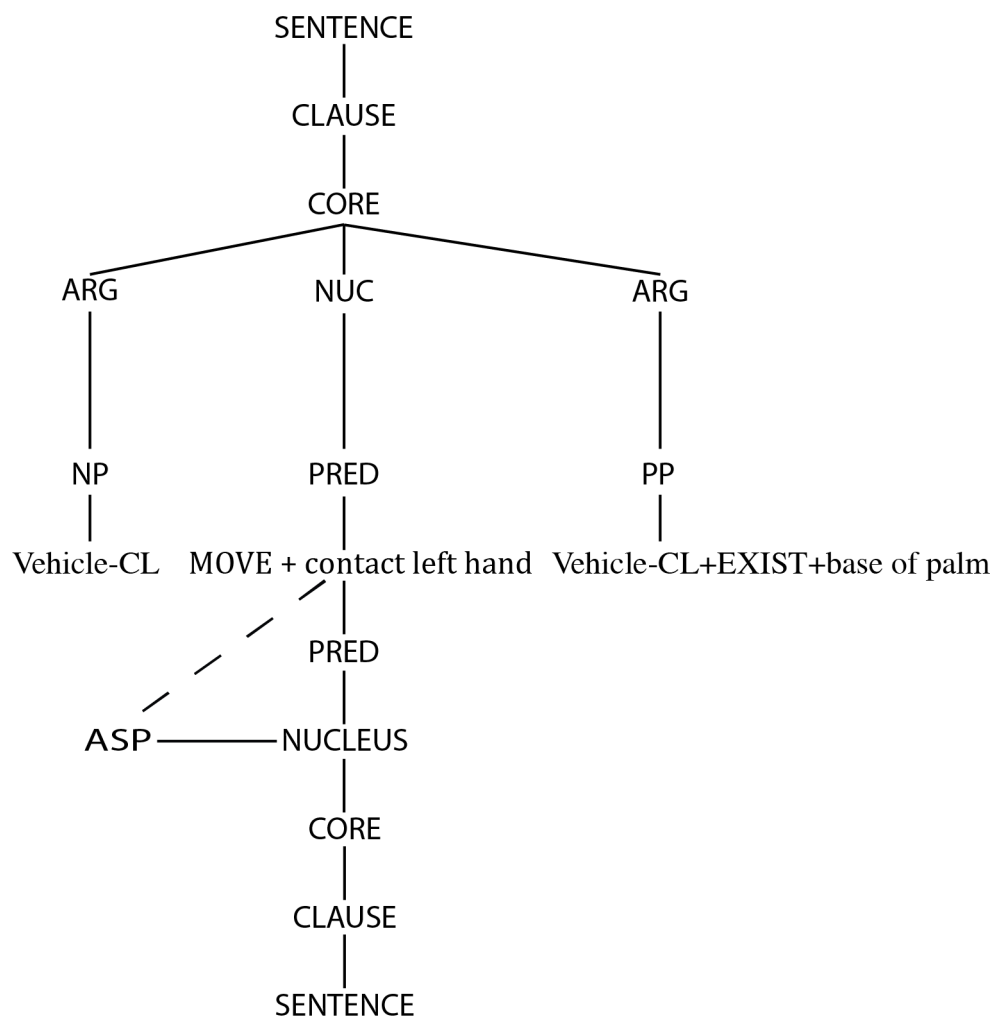


Figure 8.15 RRG constituent and operator projection ISL vehicle classifier

8.3.4 The Layered Structure of the Clause for ISL Animate Entity Classifier

In Table 8.19 we illustrate information pertaining to the sentence:

_____puffed cheeks
 dh:V-CL+MOVE+JUMP-UP-AND-OVER
 nh:Thin-vertical-entity-CL+EXIST-----

‘The dog jumped (out the window)’

SOI Corpus Fergus D. (06) Frog Story (Dublin)

Table 8.19 provides an analysis of the sentence to include transitivity, Aktionsart class and verb class. We also provide the classifier type. The classifier handshape argument represents the theme or subject of the sentence. The dog in this case has been established earlier in the discourse. The classifier handshape argument is used to denote the the dog jumped up and over, with the tips of the fingers denoting the paws of the dog. Table 8.19 also provides the extended RRG+Sign_A logical structure for the ISL sentence utilising our proposed Sign_A framework.

Table 8.19 Analysis of ISL sentence animate entity classifier

Verb Class	Transitivity	Aktionsart Class	Classifier Type
Classifier	Intransitive	Semelfactive	Whole Entity +animate Large animal
RRG + Sign_A Logical Structure			
SEML ^{xa} MOVE+JUMP-UP-AND-OVER ^{b'} <TLine><MF><NMF> (^{xa} V-CL, Flat-surface-entity-CL+EXIST----- ^b)			

Figure 8.16 provides the RRG constituent and operator projections for the sentence.

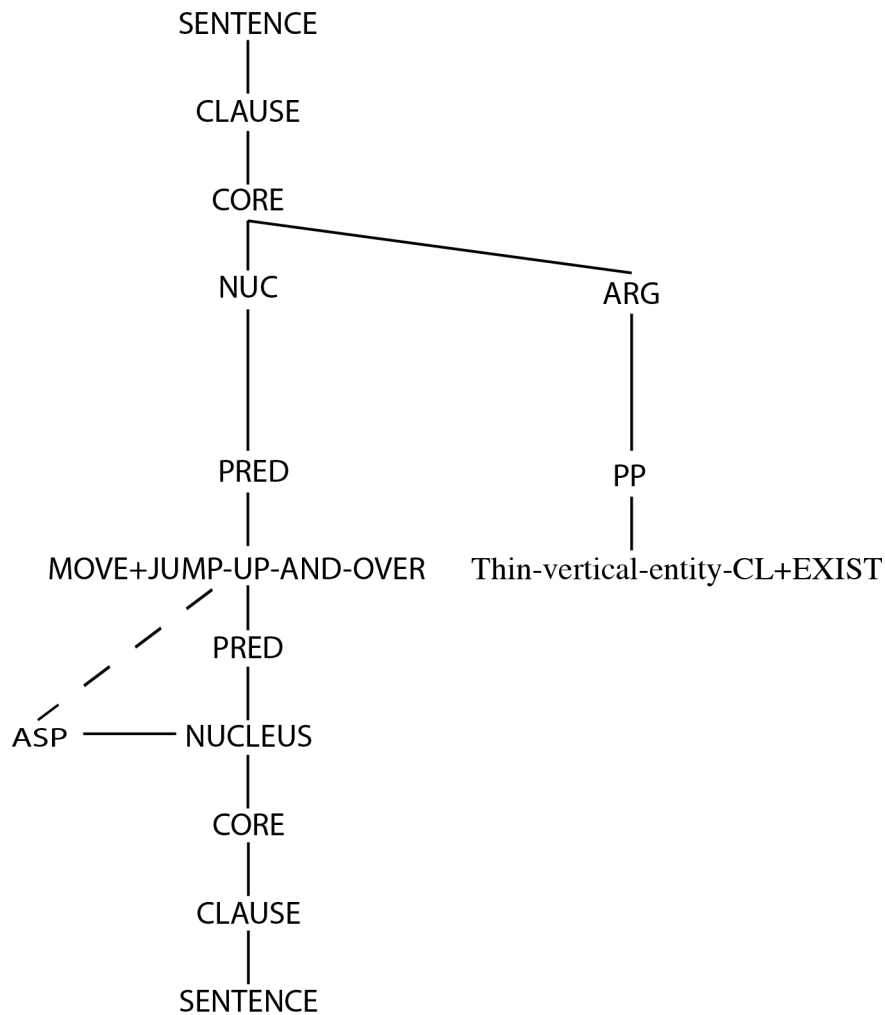


Figure 8.16 RRG constituent and operator projection ISL animate entity classifier

8.4 The Layered Structure of the Noun Phrase for ISL Nouns

This section provides illustrations of the layered structure of the noun phrase (LSNP) for ISL nouns. Bearing in mind the computational phonological parameters necessary to represent a nominal in ISL and taking into account our proposal to extend the theory of qualia (Pustejovsky, 1991) to cater for the linguistic phenomena consistent with ISL, we provide an brief overview of our proposed extension to qualia roles relating to count and mass nouns. Further to this we provide the LSNP within RRG for these ISL nouns. As discussed previously in chapter 7, we extend constitutive, formal, agentive and telic role to allow these to cater for the linguistic phenomena pertinent to an ISL noun. We leverage Articulatory Structure Level for lexical meaning, posited in chapter 4 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 at which it can be referenced. REF_{LOC} in the following examples 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 within the discourse.

8.4.1 The Layered Structure of the Noun Phrase for ISL Nouns

8.4.1.1 LSNP for ISL count noun

Example 8.1 illustrates our extension to constitutive, formal, agentive and telic role (Pustejovsky, 1991), to allow our framework to cater for the linguistic phenomena pertinent to an ISL noun. We use the Articulatory Structure Level for lexical meaning, posited in chapter 4 and also utilise a reference parameter (REF_{LOC}), which will store the (x,y,z) co-ordinates of the location within 3D space where the noun exists and can be referenced. REF_{LOC} represents the locus or (x, y, z) location parameter at which a specific entity may be referenced. REF_{LOC} will allow us to reference an entity, wherein the entity's (x,y,z) coordinates exist within the REF_{LOC} parameter.

Example 8.1

LADDER (REF y)

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

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

Agentive: **artifact**(REF y), do (x, [**BUILD'**<TLine><MF><NMF> (x,REF y)] & INGR **exist** (REF y))

In Figure 8.17 we provide an illustration of the RRG layered structure of the noun phrase for the ISL articulation of the ISL noun LADDER 'the ladder'.

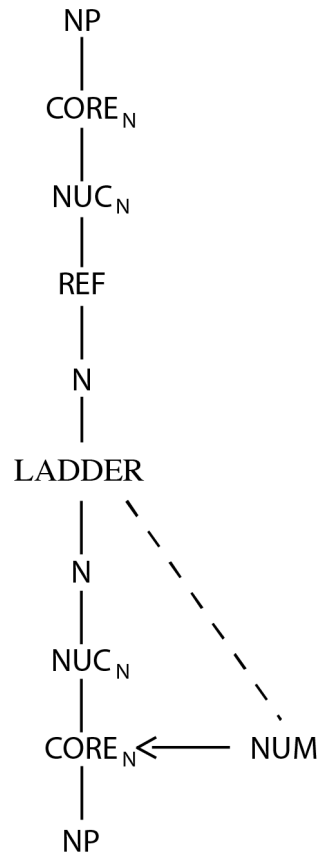


Figure 8.17 LSNP with operators in ISL LADDER

8.4.1.2 LSNP for ISL mass noun

Example 8.2 further illustrates our extension to constitutive, formal, agentive and telic role (Pustejovsky, 1991), to allow our framework to cater for the linguistic phenomena pertinent to an ISL noun, in this case a mass noun. We use the Articulatory Structure Level for lexical meaning, posited in chapter 4 and also utilise a reference parameter (REF_{LOC}), which will store the (x,y,z) co-ordinates of the location within 3D space where the noun exists and can be referenced. REF_{LOC} represents the locus or (x, y, z) location parameter.

Example 8.2

DINNER ($REF\ y$)

Const: **food items**,.....($REF\ y$)

Form: **physical** ($REF\ y$ [$\langle TLine \rangle \langle MF \rangle \langle NMF \rangle$]),

Telic: **do** (x, [$\langle EAT' \rangle \langle TLine \rangle \langle MF \rangle \langle NMF \rangle$ (x, $REF\ y$)])

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

In Figure 8.18 we provide an illustration of the RRG layered structure of the noun phrase for the ISL articulation of the ISL noun DINNER ‘the dinner’.

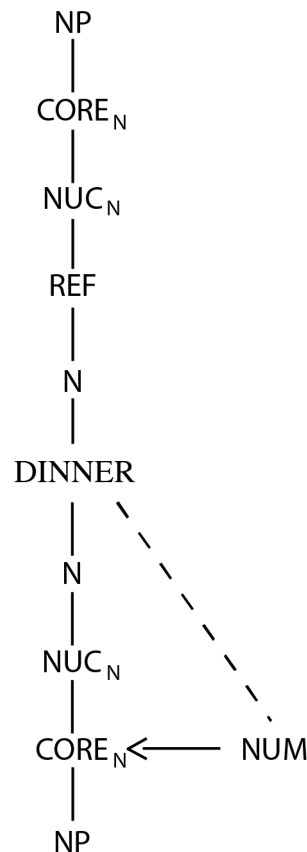


Figure 8.18 LSNP with operators in ISL DINNER

8.5 Summary

In this chapter we have addressed RQ3: How might lexical entries look for ISL classifiers, ISL verbs and ISL nouns within the RRG lexicon? We do this by providing an account of the RRG LSC and the RRG LSNP for ISL verbs, ISL classifiers and ISL nouns. We have demonstrated this account by provision of both operator and constituent projections for RRG, the theoretical framework utilised within this body of research. We provide evidence to support RQ3 and our hypothesis in relation to lexical entries for ISL verbs, ISL classifiers and ISL nouns.

We demonstrate that our linguistically motivated computational framework model has applicability to the LSC and also to the LSNP by our representation of these in terms of RRG constituent projections and operator projections for simple ISL sentences. In demonstrating this we provide a theoretical dimension that provides a common ground between spoken and signed language, in particular to this research ISL.

9. The RRG Lexeme and Morpheme Repository

9.1 Introduction

This chapter addresses RQ4. We examine the nature of ISL morphemes and lexemes with a view to defining where within the architecture of our proposed linguistically motivated computational framework, the morphemes and lexemes of ISL should reside. We provide an account of the lexicon architecture for ISL, while also defining where within this architecture the grammatical morpheme store should reside. Our initial account is of ISL morphemes, which demonstrate grammatical function, but lack conceptual meaning. Further to this we provide an account of ISL lexemes, which we describe as ISL morphemes that function in grammatical terms, while also exhibiting conceptual meaning. We provide a definition of the architecture of the RRG lexicon for ISL. We differentiate between morphemes and lexemes based on their context within any given sentence.

9.2 Irish Sign Language Morphemes

The visual gestural realisation of a word in SL may involve the simultaneous and parallel expression of a varied number of MFs and NMFs. Within this research work MFs include handshapes across the dominant and non-dominant hand in simultaneous signed constructions, NMFs include movement and/or tilt of the head, body or shoulders, movement of eyes, eyelids, eyebrows, tongue, mouth shape, crinkling of nose and also blowing of cheeks. These are the morphemes and lexemes of ISL.

9.2.1 Manual Feature Morphemes

MF phonological parameters are catered for within our proposed Articulatory Structure Level and comprise of hand configuration together with the movement of the hands from one point to another, location of the hands within 3D space and also the orientation of the palm of the hand. We propose that the 79 formational handshapes of ISL (Matthews, 2005) will reside within a morpheme store in our framework. When a predefined handshape is required it may be invoked or called

upon. The handshape will display a specific orientation depending on the articulation being communicated. The handshape may also move towards the signer or towards a specific location on or near the body. The MF handshape parameter may also move towards some other entity or location within 3D space. Those MF parameters that have conceptual meaning on the other hand must be stored within a lexeme repository for MFs. As mentioned previously in section 1.7 we use the context of an utterance to decipher whether an item should be placed within the morpheme store or within the lexeme repository of the Sign_A framework architecture. An item may exist within the morpheme store and also exist within the lexeme repository depending on the context of the item within any given sentence. ISL morphemes, which demonstrate grammatical function, but lack any conceptual meaning will be placed within a morpheme store, while ISL lexemes or those morphemes that function in grammatical terms while also exhibiting conceptual meaning will reside within a lexeme repository.

9.2.2 Non Manual Feature Morphemes

The movement and tilt of the signer's head and shoulders, the movement of the eyes, eyelids, eyebrows, tongue, mouth shape and also blowing of cheeks must be considered in relation to ISL NMF morphemes. Table 4.4, repeated here as Table 9.1, provides a definition of ISL NMF phonemes relating to each of the NMF computational phonological parameters found within ISL. Bearing in mind that NMFs are a closed set of features we propose that the NMF parameters that have grammatical function but no conceptual meaning will be stored within a morpheme store. Those NMF parameters that have conceptual meaning on the other hand must be stored within a lexeme repository for NMFs.

Table 9.1 ISL NMF Computational Phonological Parameters

ISL NMF Phonological Parameter	ISL NMF Phoneme
<HEAD>Head	nod, shake, tilt_left, tilt_right, turn_left, turn_right, chin_chest, chin_L_shoulder, chin_R_shoulder
<EB>EyeBrow (left and right simultaneous)	neutral, frown, arch
<EL>EyeLids (left and right simultaneous)	neutral, wide, squint, blink, closed
<EG>EyeGaze(left and right simultaneous)	neutral, left, right, up, down, left_up, left_down, right_up, right_down, locus, follow r hand, follow l hand
<CHK>Cheek (left and right simultaneous) Blow can be left or right singly	suck_in, blow
<MTH>Mouth	neutral, open_wide, closed_tight, smile_teeth, smile_teeth_wide, smile_closed, round_open, round_closed
<TNG> ²⁵ Tongue	in, out_pointed_1, out_pointed_2, out_pointed_3, out_round_1, out_round_2, out_round_3
<NSE>	crinkle, flare
<SHL>	neutral, up, down

9.2.3 ISL Grammatical Morphemes

The grammatical morphemes of ISL, which allow us to encode number and agreement features among others will exist within the morpheme store in our proposed framework. These morphemes, which exhibit no conceptual meaning will be defined within our morpheme repository and draw from our predefined morpheme store for ISL MF and ISL NMF once invoked from within the framework. Figure 8.2 following, reduplicated here as Figure 9.1 provides us with an illustration for the Layered Structure of the Clause based on Figure 8.4. This illustrates the Layered Structure of the Clause including operators for a simple ISL sentence displaying the use of the ISL plain verb LIKE from the ISL.

²⁵ With regard to the Tongue phonological parameter, the values 1, 2 and 3 in relation to protrusion define the percentage of the tongue, which will protrude past the lips. 1 represents 10%, 2 represents 60 % and 3 represents 100% protrusion.

REAL LIKE JOB

‘I really love my job’

Based on Example 5.2, SOI Corpus Noeleen (03) Personal Stories (Dublin)

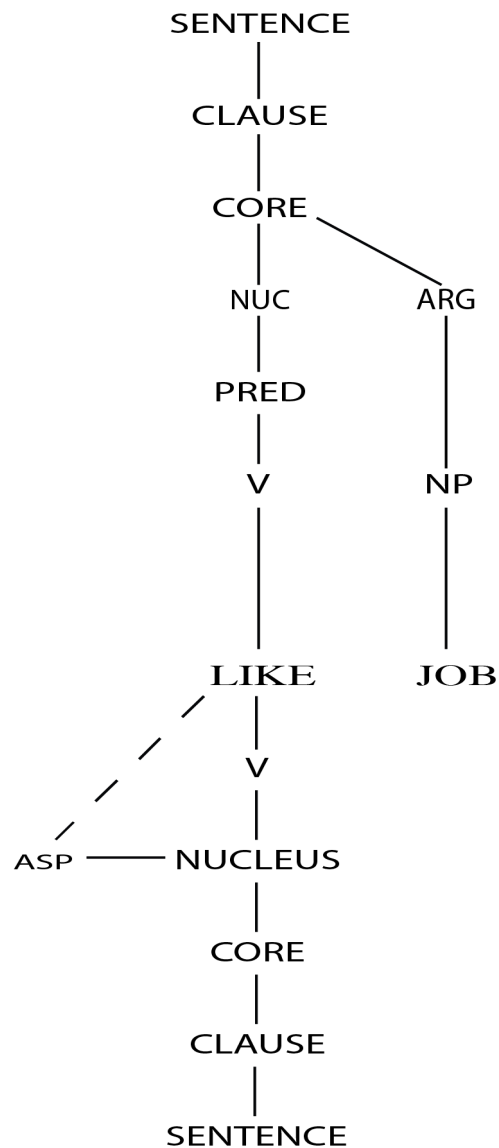


Figure 9.1 RRG constituent and operator projection ISL plain verb LIKE

9.3 Irish Sign Language Lexemes

ISL lexemes will be catered for within the RRG lexicon. Our lexicon architecture, which encompasses the rich logical structure for ISL verbs, provide lexical entries

based on the Aktionsarten system of lexical decomposition. We cater for the linguistic phenomena presented by ISL by implementing our proposed Articulatory Structure Level as a fifth level of lexical meaning (Pustejovsky, 1995). We provide a semantic representation for ISL verbs and classifiers using RRG and the Sign_A framework logical structures. Example 5.5, repeated here as Example 9.1, provides our proposed RRG+SIGN_A logical structure for the ISL agreement double person agreement verb ACCUSE. The rich logical structure is based on the associated situation type.

Example 9.1

c+ACCUSE+f

‘I blame you’

McDonnell (1996: 160, Example 5.62)

do'(c , [^aACCUSE'^b <TLine><MF> <NMF> (^a1sg , ^b2sg)]) <HS> both hands[24]

<HS> Both hands[24]

<LOC> (^a body chest) (^b pronominal reference) // marks for source and goal or subject and object

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

<ORI> palm down, fingertips forward

9.4 RRG + Sign_A Framework Architecture

9.4.1 The organisation of the RRG architecture

The following diagram (Figure 9.2) from Van Valin (2005) provides an illustration of the organisation of the RRG architecture including constructional schemata. Van Valin (2005) takes the position that constructions within RRG are utilised to capture language specific idiosyncratic linguistic behavior.

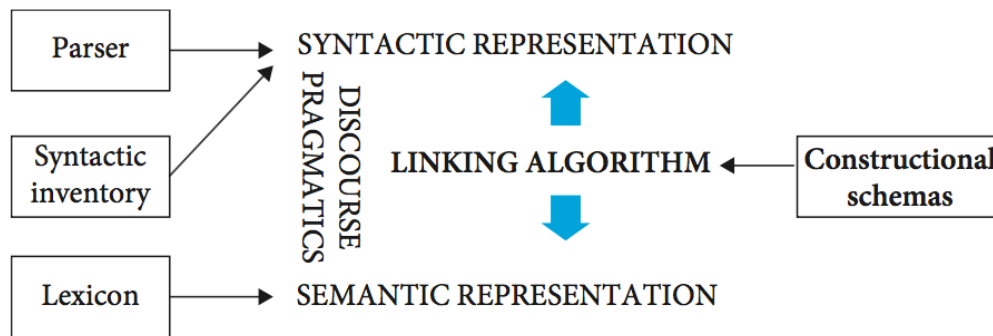


Figure 9.2 The organisation of the RRG architecture, Van Valin (2005)

Figure 9.3 provides an overview of the RRG + Sign_A framework architecture. We provide a lexeme repository, which maintains the NMF and MF lexemes of ISL. We also include a morpheme store, which maintains those grammatical units that demonstrate no conceptual meaning and a morpheme store, in which the MF and NMF morphemes of ISL will reside. The lexicon maintains the RRG + Sign_A rich logical structures for ISL.

RRG + Sign_A Framework Architecture

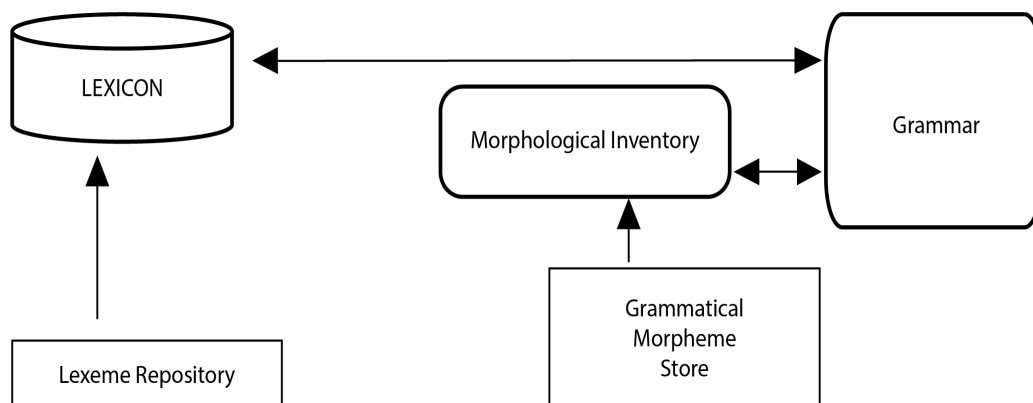


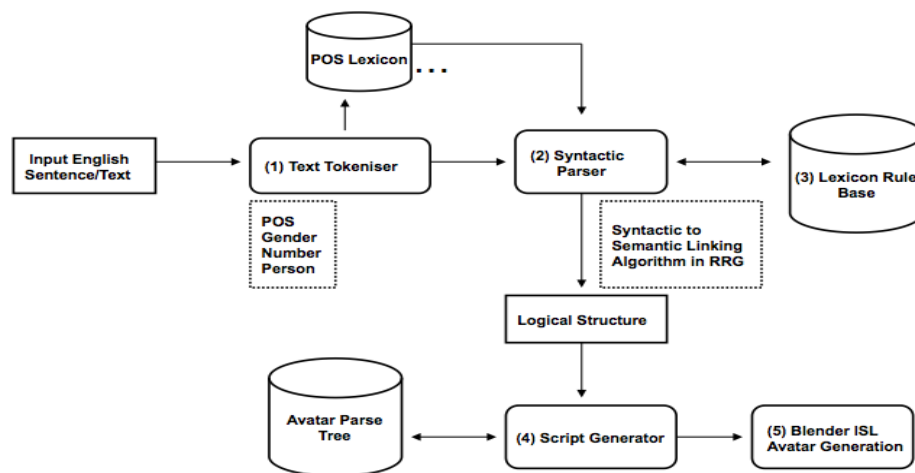
Figure 9.3 RRG + Sign_A framework architecture

The avatar that has been created within this body of work was developed with the view to informing the design of the Articulatory Structure Level and other related theoretical extensions. With regard to future work and the potential to use the Sign_A framework in the development of a Speech-To-Sign (STS) engine, Figure

9.4 documents the processes from the user inputs text until an ISL articulation is produced via an on-screen interface. It is proposed here that we would use the Blender interface as this is the tool used in the development of our avatar.

Using the RRG interlingua bridge we create an intermediate semantic representation of the source text, based on RRG+Sign_A logical structures. These logical structures can then be used to generate our target language (ISL). Figure 9.4 illustrates the proposed architecture of the parse and generate process for an ISL avatar.

This architecture describes the flow of processing.



9.5 Summary

Within this chapter we have addressed RQ4 by providing an account of the lexicon architecture for ISL, while also defining where within this architecture the grammatical morpheme store should reside. We define ISL morphemes, which demonstrate grammatical function, but lack conceptual meaning. Further to this we provide an account of ISL lexemes and define where within this architecture the lexeme repository should reside. We also provide a definition of the architecture of the RRG lexicon for ISL. While we provide a linguistically motivate computational framework, future work may involve evolution of this framework, particularly as

further research is carried out on the linguistic of ISL in the areas of the structure of the signing space, the relationship to discourse common ground and also pragmatic ellipsis in ISL.

10. Future Work and Concluding Discussion

This research is concerned with the architecture of the lexicon for Irish Sign Language (ISL) in computational terms and the challenges involved in the development of a lexicon architecture that is capable of representing lexical information pertinent to ISL and the lexical definition of a SL word (Zeshan, 2007).

SLs are visual gestural languages articulated in a signing space (Murtagh 2011a, 2011b, 2011c). SLs have no written form. ISL (O'Baoill and Matthews, 2000; Leeson and Saeed, 2012) is a linguistically complete and very complex language. Communication occurs using a visual-gestural modality, encompassing manual and non-manual features. Manual features make use of hand shapes, hand locations, hand movements and orientations of the palm. Non-manual features include the use of eye gaze, facial expression, head and upper body movements. 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.

The objective of this research is to define a lexicon architecture that is sufficiently universal and robust to accommodate the linguistic phenomena consistent with SLs, in particular to this research ISL, in linguistic terms. To date, there has been no definition for the architecture of the ISL lexicon in computational terms. ISL is a visual gestural language articulated in 3D space with no aural or written form.

We demonstrate a definition for ISL lexical entries capable of representing ISL using Role and Reference Grammar (RRG), a structural functionalist theory of grammar, and our proposed Sign_A framework in this development. We demonstrate that RRG is the most appropriate framework for utilisation in the development of our computational linguistic framework and argue that RRG is robust and universal enough in nature to represent ISL, a visual gestural language with no written or aural form. We argue that our newly proposed framework architecture must provide a morpheme store and a lexeme repository to store the morphemes and lexemes for ISL, while also providing an RRG + Sign_A rich logical structure semantic representation for ISL verbs and nouns, which will reside within the RRG lexicon.

As an approach to represent ISL in linguistic terms we argue that the theory of qualia structures defined within the theory of the Generative Lexicon (GL) (Pustejovsky, 1995), must be extended to allow for SLs and the associated linguistic phenomena. We have argued that semantic properties, which contribute to the meaning of a sentence will need to be extended to accommodate ISL. We also argue that in terms of lexical meaning for ISL that we must introduce a new level of lexical meaning, such that the phonological parameters associated with this visual gestural language are sufficiently accommodated. We have motivated a new level of lexical meaning termed Articulatory Structure Level. This level of lexical meaning will represent the essential (computational) phonological parameters of an object as defined by the lexical item. These parameters will be used to account for various linguistic phenomena pertaining to ISL MFs and NMFs, which are necessary to adequately represent ISL within our computational framework. We refer to our newly developed framework as the Sign_A framework. We utilise this framework, which leverages our proposed Articulatory Structure Level for lexical meaning to accommodate the linguistic phenomena consistent with ISL.

The four research questions that this dissertation addresses are:

RQ1. To what extent can RRG account successfully for ISL sentence structure?

RQ2. How do we motivate the phonological-morphological interface in ISL?

RQ3. How might lexical entries look for ISL classifiers, ISL verbs and ISL nouns within the RRG lexicon?

RQ4. What is the appropriate linguistically motivated computational architecture for ISL and where within this architecture should the ISL grammatical morpheme repository reside?

We have developed an avatar and utilised our avatar in computational terms to motivate feature selection underpinning the coding of the phonological/morphological interface of ISL. We have argued a new level of lexical meaning, Articulatory Structure Level and we have leveraged this in the development of RRG logical structures capable of representing ISL verb and noun lexical entries.

In chapter 2 we have investigated ISL to include the evolution of the language and the challenges that Deaf or hard of hearing people face in terms of access to information and education in Ireland today. This provides us with a motivation for this body of work. The development of a linguistically motivated computational framework for ISL will provide the potential for many very interesting and broad reaching innovations in terms of technology for ISL. Among these is the potential of a text-to-sign engine with the implementation of an intelligent agent or avatar, which could be used to articulate ISL in real time. Providing this type of technology may help alleviate the difficulties members of the Deaf community face in a day-to-day basis.

We have prepared to address RQ1 in chapter 2, where we explored the linguistics of ISL and provided an account for the phonetics and phonology of ISL, providing the 66 handshapes identified by O'Baoill and Matthews (2000). Thorvaldsdottir (2010) has accounted for handshapes further to the 66 handshapes identified by O'Baoill and Matthews (2000), bringing the total to 79 handshapes for ISL (Matthews, 2005). We have explored the signing space and identified ISL MF and NMF phonological parameters. We have also explored ISL in terms of morphology, identifying signs in SL as being situated at the level of words in spoken language (Zeshan, 2002). We have considered the phenomenon of polysemy within ISL and have identified that polysemous signs do exist within the language. Due to the fact this lexical ambiguity is a critical topic with regard to natural language processing, this is any area that warrants further investigation in the future. We have investigated phonemes and morphemes in ISL and concluded that iconic signs challenge the traditional divide between phonemes and morphemes found in spoken language with the term *phonomorpheme* being a more suitable descriptor for iconic signs, which function as both phonemes and morphemes (Meir, 2012). We explored ISL verbs and nouns (including noun plurals). We have found that SL verbs are traditionally categorised according to Paddens tripartite theory (Padden, 1998) in which SL verbs are defined as being *plain*, *agreeing* or *spatial*.

We have also investigated ISL classifier predicates and report four different categories of classifier found in ISL (Leeson and Saeed, 2012). We have explored ISL in terms of the syntax of the language. ISL nouns can be re-duplicated and can

also be modified by adjectives. In a case where a noun is modified by an ²⁶adjective, Leeson and Saeed (2012) have identified that the adjective typically occurs pre-nominally, where the adjective generally precedes the noun. In terms of pronouns, ISL makes use of anaphoric and deictic reference to map referents to locations in the signing space. The remaining chapters within this dissertation also address RQ1, following on from our initial overview of the literature for SLs, in particular to this research ISL, in chapter 2.

We have addressed RQ2 in chapter 4, where we defined the various computational phonological parameters that are necessary to represent ISL MF and NMF in computational linguistic terms. We motivated the development of an avatar within 3D space and leveraged the avatar in the development of computational phonological parameters necessary to represent ISL within the RRG lexicon. An innovation of this research is that we have re-defined the signing space for ISL in linguistically motivated computational terms. We defined new body anchored computational phonological parameters, new MF and NMF computational phonological parameters and we also defined new parameters relating to time, namely *timeline* and *eventDuration*.

Further innovation of this research is found in chapter 4, where we argue that with a view to representing ISL, the GL theory of Lexical Representation (Pustejovsky, 1991) should be extended to include an additional level of representation for SL. It is argued that this entirely new level of representation for lexical meaning is necessary to capture the linguistic phenomena consistent with ISL in order to truly represent and accommodate ISL in linguistic terms. This new level of lexical knowledge is referred to as *Articulatory Structure Level*. Articulatory Structure Level will be utilised in the lexical representation of Signed Languages, enabling the essential (computational) phonological parameters of an entity to be referred to and defined.

²⁶ An adjective being one of the main grammatical categories within ISL and behaving as a modifier to a noun.

We paved the way to further addressing RQ3 and RQ4 in chapter three, by providing an account of Role and Reference Grammar (RRG) a theory of grammar concerned with the interaction of syntax, semantics and pragmatics in grammatical relations. As RRG has been developed with spoken languages in mind, the analysis of languages expressed in a visual gestural modality test the strength of the theory and this work contributes by ensuring that the theory is modality-neutral.

We have also addressed RQ3 in chapter 5, chapter 6, chapter 7 and chapter 8, where we demonstrated an account of lexical entries for ISL verbs, ISL classifiers and ISL nouns within the RRG lexicon. We utilised our newly motivated Sign_A framework in this development. In chapter 5 we addressed RQ3 by defining what the lexical entries for ISL verbs might look like within the RRG lexicon. We further investigated the literature in relation to SL verbs, specifically ISL verbs. We analysed various verb types from the SOI corpus and subsequently categorised these according to the ISL verb category, transitivity and event type. Our investigation of ISL verbs and the associated Aktionsart classes demonstrates that ISL shows linguistic correlates for five situation types: states, activities, achievements, accomplishments and semelfactives. Our analysis of ISL verbs in relation to Wilbur (2008) and the Event Visibility Hypothesis (EVH) demonstrates ISL verb behavior is in agreement with Wilbur's hypothesis. Within this chapter we leverage our previously defined computational phonological parameters and the Articulatory Structure Level of lexical meaning to provide the RRG logical structures for the ISL plain and agreement verbs based on their respective event type. We also use EVH in our definition of RRG logical structures for ISL verbs.

In chapter 6 we also address RQ3 by providing a definition for lexical entries for ISL classifiers. We briefly report on classifiers in spoken and SLs. We further examine the literature in relation to SL classifiers to provide an insight into the complexities of these morphologically complex units within ISL. We report on the ISL handshapes for ISL classifiers. We also report on the four different categories of classifier realised within ISL (Leeson and Saeed, 2012). We utilise the SOI corpus in the analysis of ISL classifiers identifying specifically the ISL verb class, transitivity, Aktionsart class, classifier category and RRG logical structure. Using this information we produce a rich logical structure capable of representing ISL

within the lexicon. We again refer to the Articulatory Structure Level of lexical meaning, an extension to Pustejovsky (1991) and the theory of the GL to cater for the various linguistic phenomena consistent with ISL, a visual gestural language, in terms of lexical entries.

In Chapter 7 we also address RQ3 by providing a definition for the lexical entries for ISL nouns and the layered structure of the clause within the lexicon. We report on ISL nouns and operators that modify the noun. We also report on how ISL nouns are referenced within ISL discourse and the various methods used by signer's to communicate information pertaining to these highly complex linguistic units. We report on both anaphoric and deictic reference and also the underpinnings of pronominal reference in ISL (Leeson and Saeed, 2012). We provide a linking mechanism in terms of mapping pronominal reference to specific (x,y,z) locations within 3D space in relation to the signer. We also look to GL qualia theory (Pustejovsky, 1995) and we argue that to accurately represent ISL nouns in computational linguistic terms and within the ISL lexicon, we must extend the theory of qualia to cater for the linguistic phenomena, which manifests itself within ISL nouns. We argue that must extend the definition of lexical items to cater for ISL nouns, catering for the visual gestural modality of the language. We posit that we must extend *constitutive*, *formal*, *agentive* and *telic* roles (Pustejovsky, 1995) to allow qualia theory to cater for the linguistic phenomena pertinent to nouns within ISL. An innovation of this research is that we implement a parameter termed REF_{LOC} which extends itself as a placeholder to the (x,y,z) co-ordinates of the location within 3D space that the noun exists and can be referenced. We leverage the Articulatory Structure Level for lexical meaning, an extension to Pustejovsky (1991) and the theory of the GL to cater for the various linguistic phenomena consistent with ISL, a visual gestural language in terms of lexical entries. We use our Articulatory Structure Level to leverage our development of a rich logical structure for ISL noun entries. We articulate the linking system from the lexicon to include extended lexicon representation into visual syntax for ISL nouns.

In chapter 8 we also address RQ3 by providing an account of the RRG LSC and the RRG LSNP for ISL verbs, ISL classifiers and ISL nouns. We provide evidence to support our hypothesis in relation to lexical entries for ISL verbs, ISL classifiers

and ISL nouns. We demonstrate that our linguistically motivated computational framework model has applicability to the LSC and also to the LSNP by our representation of these in terms of RRG constituent projections and operator projections for simple ISL sentences.

Chapter 9 addresses RQ4 by providing an account of the architecture of the RRG lexicon for ISL. We examined the nature of ISL morphemes with a view to defining where the morphemes and lexemes of ISL should reside within the architecture of our proposed linguistically motivated computational framework. Our initial account is of ISL morphemes, which demonstrate grammatical function, but lack any conceptual meaning. Further to this we provide an account of ISL lexemes; ISL morphemes that function in grammatical terms while also exhibiting conceptual meaning.

This research highlights the importance of linguistic analysis in the construction of a robust system for ISL parsing and generation. At a time when probabilistic approaches overwhelm the domain of computational linguistics, this research provides critical thinking in relation to the benefit of using linguistic theory with regard to the processing of SLs, in particular to this research ISL. The unique contribution of this research is that it fuses a constructional perspective in important phenomena in SLs, in particular to this research on ISL, in an RRG context. Within this body of work we have motivated a new level of lexical meaning for language termed the Articulatory Structure Level. This level of lexical meaning caters for the linguistic phenomena pertinent to SLs, which have no written or aural form and occur in a visual gestural modality. We argue for this new level of lexical meaning as an extension to GL theory (Pustejovsky, 1991). This new level of lexical meaning describes the essential (computational) phonological parameters of an object as defined by the lexical item. This new level of lexical representation has the potential to be utilised also in terms of the linguistics of signed and spoken languages.

We demonstrate innovation within this research and also contribute to knowledge within the domain by leveraging the development of an avatar within 3D space in the provision of computational phonological parameters capable of representing ISL within a lexicon architecture. We argue that new parameters for timeline and

eventDuration must be included in terms of computational phonological parameters for ISL. We also argue a new definition in terms of the signing space for ISL and body anchored parameters for ISL in linguistically motivated computational terms.

We provide further contribution to knowledge in our motivation for a new parameter termed REF_{LOC} which extends itself as a placeholder to the (x,y,z) co-ordinates of the location within 3D space that ISL nouns exist and can be referenced. We argue for an extension to *constitutive*, *formal*, *agentive* and *telic* role (Pustejovsky, 1995) to allow qualia theory to cater for the linguistic phenomena pertinent to nouns within ISL.

With regard to future work relating to this research, it is planned to investigate handle entity, extension and body CL stems with a view to providing an account of these in terms of RRG lexicon entries leveraging the Sign_A framework. The structure of the signing space, the relationship to discourse common ground and also pragmatic ellipsis in Sign Language is an area that warrants further investigation. SLs are indigenous languages that evolved naturally. As polysemy is a critical issue within the domain of natural language processing, future work on polysemous signs and lexical polysemy within ISL and also investigation into an approach to address this phenomenon within our framework is also necessary. It is anticipated that providing the sense of which lexeme is being used within any given utterance will be an interesting yet challenging area of future research. Future work will include defining the distinct senses a lexeme has, defining how these sense are related and also defining how they can be reliably distinguished.

Future work will also be carried out on the investigation of ISL adjectives and colour terms. To date the literature in this area is lacking and there is scope for further investigation to provide a richer account of the linguistics of ISL within this domain. Future work in relation to the Sign_A framework architecture will pivot around the role of a construction repository within the RRG lexicon architecture. Van Valin (2005) takes the position that constructions within RRG are utilised to capture language specific idiosyncratic linguistic behavior. Further investigation in relation to the architecture for our linguistically motivated computational framework will be carried out with a view to leveraging the use of constructions within RRG as defined by Nolan (2011a, 2011b, 2011c), where a construction may

be viewed as a grammatical object within a construction repository. Using this approach, the importance of the lexicon within our architecture would be retained, with a construction being viewed as a grammatical object within the RRG architecture that inherits from the lexicon. An investigation as to where the construction repository will reside within the architecture will also be carried out. Future work will also be carried out in relation to furthering the development of a text-to-sign synthesis engine, leveraging our avatar and the Sign_A framework, while using RRG as the underlying theory of grammar.

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