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Intonation in Anglesey Welsh

Cooper, Sarah

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INTONATION IN ANGLESEY WELSH

Sarah E. Cooper

School of Linguistics and English Language

Bangor University

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Abstract

This thesis investigates the intonation system of Anglesey Welsh, an under researched variety with regards to its suprasegmental aspects. The main aim of this thesis is to provide a fine-grained intonational investigation into the realisation of the structural components of the intonation system. The secondary aim considers a functional hypothesis proposed by Haan (2002), that there may be a trade-off between the amount of lexico-syntactic marking used to cue interrogativity (e.g. inversion, wh-words) and the amount of intonational marking (e.g. higher and later accent peaks).

With regards to the phonetic realisation of the structural elements, two features are investigated: the vertical *scaling* (or height) and the temporal *alignment* to the segmental string. The materials were manipulated to test the effect that a) grammatical function and b) temporal constraints had on the scaling and alignment of the structural components.

The results show that the scaling (height) was significantly affected by the grammatical function of the test sentences, with the structural components in questions being realised higher than statements. With regards to alignment, there was evidence of significant adjustments in the location of some structural components as a function of the number of syllables available in the sentence.

The final part of this thesis discusses issues surrounding a phonological analysis of the intonation system using the scaling and alignment data. It is proposed that Anglesey Welsh questions and statements are best analysed as having a rising L+H* in both prenuclear and nuclear position, followed by a low boundary tone L%.

This thesis contributes to knowledge on prosodic typology by analysing the structure and function of the intonation system using a widely used approach to intonational analysis (the autosegmental-metrical approach). Furthermore, it tests questions about the phonetic implementation of intonation in Anglesey Welsh and uses the patterning to discuss an appropriate underlying phonological representation of the intonation.

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List of Abbreviations

General abbreviations

AM	autosegmental-metrical
DQ	declarative questions
F0	fundamental frequency
ip	intermediate phrase
IP	intonational phrase
IViE	Intonational Variation in English (also, the labelling system) (Grabe et al., 1998)
ST	statements
ToBI	Tone and Break Indices, developed by Beckman and Hirschberg (1994)
ToDI	Transcription of Dutch Intonation described in depth in Gussenhoven (2005)
WQ	wh-questions
YQ	yes-no (polar) questions

Gloss abbreviations

3PL	3rd person plural
3S	3rd person singular
DET	determiner
IMP	imperfect
NEG	negative
NONFIN	non-finite
PAST	past tense
PRES	present tense
PRT	particle
OBJ	object
SUB	subject
AUX	auxiliary
V	verb
PRON	pronoun

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Chapter One

Introduction and Background

Intonation is used primarily in spoken language for the structuring of information and is key feature of speech found in all languages (Hirst and Di Cristo, 1998: 1). It is defined by Ladd (2008a: 4) as the use of *suprasegmental phonetic features* at the *sentence-level* as a way of conveying *linguistically structured meaning* (Ladd, 2008a: 4). Roach (1983: 112) notes that most definitions of intonation "recognise that the pitch of the voice plays the most important part". The pitch of the voice can also be used to reveal to a listener other non-linguistic information (such as sex and age) or paralinguistic information (such as attitude or emotion). The study of intonation involves the interaction of phonetics, phonology and pragmatics. As a result, the position of intonation within the field of linguistics is known to be complex (Beckman, 1995). Its structure is not as straightforward to analyse and describe as structures found in syntax or morphology (Gussenhoven, 2004).

Intonation is a feature of speech that can be under-acknowledged, despite the fact that it is an integral part of everyday speech. This is very much the case with northern Welsh, a variety which has, until now, been overlooked in terms of research into its suprasegmental phonetic features. This thesis focuses on the *linguistic* function of pitch in Anglesey Welsh and how it is used to convey grammatical meaning. In doing so, this thesis targets a major deficit in our knowledge about the suprasegmental structure of Welsh in general (Ball and Williams, 2001). The analysis of undescribed languages and varieties of languages is also important in contributing to the understanding of the structure of intonation. This thesis will not only contribute to knowledge on prosodic typology by analysing the structure and function of the intonation system, but it will also test a) questions about the phonetic implementation of intonation, specifically the scaling (height) and temporal alignment of structural components which make up the intonation contour and b) questions in the field of intonational phonology with regards to the transcription of intonational events. This latter point forms a central part of a discussion later in the thesis.

Thesis structure

This thesis is divided into 6 chapters. The first chapter will provide an introduction to the basic concepts of intonation. Chapter 2 provides an introduction to the Welsh language, focussing on its linguistic structure with regards to a) its basic syntax and b) the suprasegmental features that have been investigated thus far. Chapters 3 and 4 are the first two results chapters focussing on the scaling (height) and temporal alignment of points in the intonation contour. Chapter 5 provides a reaction to the autosegmental-metrical models of intonation (ToBI, ToDI and IViE) and uses the findings from Chapters 3 and 4 to draw a discussion of the phonological structures found in Welsh intonation. Finally, Chapter 6 revisits the major findings and concludes the thesis.

1 Intonation

As discussed above, this thesis aims to provide an analysis of the intonation system in Anglesey Welsh by considering a) the phonetic realisation of the structural components and b) its phonological structure. This section will begin by considering Ladd's (1996; 2008a) definition of intonation before moving on to discuss the issues underlying *the phonetics of intonation* and *the phonology of intonation*.

Ladd's (2008a: 4) widely accepted definition states that intonation refers to "the use of *suprasegmental* phonetic features to convey post lexical or *sentence level* pragmatic meanings in a *linguistically structured* way" (emphasis in original). As such, this definition covers three important characteristics: "suprasegmental phonetic features", "sentence level pragmatic meaning" and "linguistically structured".

The *suprasegmental phonetic features* are those features that operate above the level of the phoneme: syllables, words, phrases etc. The view adopted in this thesis is that intonation primarily involved the modulation of pitch, although it is important to note that other suprasegmental prosodic features such as loudness and duration are closely bound to the patterning of pitch (Nolan, 2006: 433).

The second characteristic in Ladd's definition: *sentence level pragmatic meaning* refers to intonation conveying meanings that apply to constituents larger than the word. Intonation is not the only linguistic device that involves the use of pitch in languages (Nolan, 2006: 434). Many languages around the world (e.g. Mandarin Chinese, Burmese, Thai, Hausa) use pitch tones to distinguish words. These languages not only distinguish words by using vowels and consonants, but also use "a limited set of distinctive pitch patterns or heights on each syllable" (ibid: 434). Languages that make extensive use of pitch in the distinguishing of words are known as *tone languages*. However, some languages such as Swedish, Japanese and Korean use pitch to distinguish a limited number of words, and these languages are known as *lexical* or *pitch accent languages*. *Tone languages* and *lexical (pitch) accent languages* also feature intonation, but the extent to which they do so may vary dependent on the scope of a language's use of pitch for distinguishing words (ibid. 434). However, the study of intonation is concerned mainly with constituents larger than the word; "phrases or utterances as a whole, such as sentence type, speech act… etc." (Ladd, 2008a: 6) and as such, this thesis focuses on the use of pitch to indicate post-lexical meaning in Anglesey Welsh.

The final characteristic: *linguistically structured* denotes that the features of intonation are organised as "categorically distinct entities (e.g. low tone or boundary rise) and relations (e.g. stronger than/ weaker than)" (ibid. 6). That is, there are smaller building blocks of intonation that are organised in a linguistically structured way.

These three main characteristics will be returned to in this chapter (and thesis) in more depth. However, in relation to the first characteristic, this chapter will firstly consider a brief discussion of the physiology and acoustics of these *suprasegmental phonetic features*.

The physiology and acoustics of intonation

The pitch of the voice is generated by the vibration of the vocal folds, two muscles that are situated halfway down the larynx held by the thyroid cartilage to the front and two small triangular arytenoid cartilages to the rear. The arytenoid cartilages control a certain amount of tension in the vocal folds: they can be held apart allowing non-impinged air intake or escape (Gussenhoven, 2004: 1) or can be held very close together. When they are held close together, the vocal folds are pressed together and the sub-glottal pressure of the airflow from the lungs in exhalation increases. This eventually prises the vocal folds open and the air escapes through the glottis. The resulting drop in air pressure after the release means that the vocal folds can once again close under the tension from the arytenoids. The sub-glottal pressure will again increase, prising the glottis open and restarting the process, which will continue while the arytenoids are held with this same tension. This opening and closing action, if heard more than 40 times per second is perceived as the continuous event of voicing. The pitch of the voice alterns with increased longitudinal tension in the vocal folds. When the tension in the vocalis muscle (which lies parallel with the vocal folds) changes, the vocal folds vibrate at different rates.

It must be noted that 'pitch' is the *auditory* correlate of the rate of vibration of the vocal folds while 'fundamental frequency' (F0) is the *acoustic* correlate of the rate of vibration of the vocal folds in voiced sounds (Lehiste, 1970). F0 is expressed in Hertz (Hz), the number of cycles of vocal fold vibration (or periods) per second. The faster the vocal folds vibrate, the more periods per second and the higher the F0 of the sound produced (Gussenhoven, 2004: 2). Ladd (2008a: 5) notes, the terms *pitch* and *F0* are used interchangeably “in many contexts outside psychophysics”. Variation in fundamental frequency is studied primarily through consultation with pitch tracks produced by computers. Pitch tracks plot frequency against time and provide a visual representation of F0 variation in the utterance (Gussenhoven, 2004: 5).

As mentioned previously, the pitch of the voice can be controlled to convey sentence level meaning, for example to indicate the difference between question and statement. As the field of intonation has developed, theoretical frameworks have emerged which aim to model underlying structures of intonation. The following section outlines the theoretical framework upon which this thesis is based: the autosegmental-metrical approach.

2 The autosegmental-metrical (AM) approach to the study of intonation

The development of the field of intonation advanced greatly towards the end of the last century with the AM approach becoming the predominant method for analysing intonation. This section will outline some of the history behind the AM approach including a brief consideration of Pierrehumbert (1980). It will also outline some of the main assumptions underlying current AM theory (according to Ladd, 2008a) and will consider some important issues regarding the phonetic realisation and phonological representation of intonation.

Prior to the establishment of AM studies of intonation, much of the research in the field was focussed around two schools, which Ladd (2008a: 10) terms the “instrumental” approach and the “impressionistic” approach. The early *instrumental* work on intonation focussed on the ‘acoustic correlates’ of communication, such as interactional meaning (continuation etc.) and emotion (anger, surprise etc.) (see Lehiste, 1970 for an overview of these studies). The early *impressionistic* approaches encompassed two schools: the American structuralist school (Pike, 1945; Trager and Smith, 1951) and the British School (e.g. O’Connor and Arnold, 1973; Halliday, 1967; Crystal 1969). Both of these schools break the intonational unit into “a small number of categorically distinct elements” (Ladd, 2008a: 10). The American structuralist school postulated pitch levels / phonemes such as "extra high", "high", "mid" or "low" assigned to each syllable while the British school postulated that movements like a "rise" or "fall" were central to the structure of intonation. Much of the early research was based on observations of the scholar rather than on experimental data (Ladd, 2008a: 11) and "the authors of these descriptions had no ambitions to go beyond data that could be gathered by traditional auditory methods and written down as impressionistic pitch curves". By the end of the 1970s, the AM approach to the study of intonation had begun to emerge, evidenced in great depth in Pierrehumbert (1980).

Pierrehumbert (1980)

The foundations of the AM approach and the application to post-lexical intonation began with the work of Pierrehumbert (1980). Pierrehumbert's approach outlined the phonological components of intonation supported by a set of rules that map the abstract representation into an acoustic (phonetic) signal. In this approach, the assignment of an intonational element to every prominent syllable (as had been done in the British and American structuralist schools) was viewed as excessive and unnecessary (Pierrehumbert and Beckman, 1988).

Pierrehumbert proposed a phonological representation of English intonation, building on the work of Liberman (1975), Goldsmith (1976) and Bruce (1977). Pitch tunes were for the first time analysed as strings of high (H) and low (L) tones associated with certain syllables. The syllables are usually prominent in some way in comparison with the surrounding syllables in the same utterance. This relative metrical prominence of certain syllables formed the foundation of Pierrehumbert's analysis. The analysis contained a metrical grid for the text of the phrase on which the structure of the tune (the L and H tones) was aligned: the metrically most prominent syllables within the text were those which were expected to feature a tone (*a pitch accent*) and the edges of prosodic units also had tones associated with them (*edge tones*).

Pierrehumbert introduced a notation system in order to label which H and L tones are associated with metrically strong syllables or the ends of prosodic units. The star notation (*) is generally taken to indicate that the pitch accent associates with a metrically strong syllable. Pitch accents may also consist of more than one tone, indicated with a plus sign (+) between the two tones. In bitonal pitch accents, one of the tones is stronger than the other: and this is the one that is marked by the star. In Pierrehumbert's model, an unstarred tone may precede (lead) or follow (trail) a starred tone. Pierrehumbert distinguishes seven types of pitch accent in her finite state grammar. These are monotonal H* and L* (a H or L tone aligned with the metrically strong syllable) or bitonal L*+H, L+H*, H*+L, H+L* and H*+H.

Furthermore, two types of edge tone are outlined in Pierrehumbert (1980): boundary tones (marked '%'), associated with the edge of the larger Intonational Phrase (IP) and the phrase accented (marked '-') an unstarred tone occurring between the last pitch accent and the final boundary tone (see section headed 'Phrasing and structure' below. These pitch accents, phrase accents and boundary tones in her finite state grammar combine to form sequences of 22 legal tunes in English (see Pierrehumbert, 1980: 29).

Pierrehumbert's thesis was the first to separate phonological primitives (H and L tones) and sparsely associate them with metrically prominent syllables. The shape of the intonation contour between subsequent pitch accents is a result of *interpolation*. This principle provides the basis for the AM framework (categorical phonological representation is distinguished from the gradient phonetic realisation). This brief section on Pierrehumbert's landmark thesis has outlined some of the basic principles that have formed the foundations for further research into intonation. The next section will outline some of the assumptions (following Ladd, 2008a) that are said to underlie current autosegmental-metrical research.

Autosegmental-metrical assumptions

In his review of the AM approach, Ladd (2008a: 44-80) outlines four main assumptions underlying the current AM theory which have stemmed from the early work of Pierrehumbert (1980), Beckman and Pierrehumbert (1986) and Pierrehumbert and Beckman (1988):

- Sequential tonal structure

The structure of the tones is composed of a "string of local events" which associates with the segmental string. These local events occur *only* with metrically strong, accented syllables (i.e. those which are more prominent than others in the utterance (Pierrehumbert and Hirschberg, 1990)). This concept, more recently labelled *sparse tonal specification* (Arvaniti and Ladd, 2009) leaves the pitch contour phonologically "underspecified" (Ladd, 2008a: 44); the pitch contour between the tonal events is merely a transition or interpolation. The AM approach revolves around this string of events that comprise: a) pitch accents associated with these metrically strong syllables and b) edge tones which are associated with the edge of prosodic units.

- Distinction between pitch accent and stress

As described above, the pitch accents are intonational features that are associated with the accented or rather metrically strong syllables due to "principles of prosodic organisation", not stress. Pitch accents may, in some languages, coincide with stress, but pitch accents and stress are separate entities. This dissociation between pitch accent and stress has been suggested to be the case for Welsh, which is traditionally said to have penultimate stress. However previous researchers (Jones, 1949; Watkins, 1961; Rees, 1977, amongst others) have suggested that Welsh distinguishes between "stress" on the penultimate syllable and "accent" (indicated by increased pitch) on the final syllable. For further discussion of the relationship between stress and pitch in Welsh, see Chapter 2.

- Analysis of pitch accents in terms of level tones

The structural components of pitch accents and edge tones are composed as *level tones* that can be High (H) or Low (L). These can appear as single tones (monotonal) or can be combined (bitonal). When there is a pair of tones in a pitch accent, a "strength relation" (Pierrehumbert, 1980: 236) is defined. The most metrically strong syllable carries the starred tone while the unstarred tone can occur "off the syllable which is assigned the accent phonologically" (ibid. 239) (i.e. the preceding or following syllable). The most common interpretation of the star notion since Pierrehumbert "is that the starred tone (is) phonetically aligned with the stressed syllable" (Arvaniti et al., 2000: 120). This characteristic will form a central part of this thesis; the phonetic realisation of the intonation contour will be investigated in terms of high and low *tonal targets*. The investigation of relationships between these tonal targets will form the basis for analysis of the organisation of underlying level *tones* into pitch accents.

- Local sources for global trends

The scaling or *height* of an H or L tone depends on a number of factors (position in utterance, emphasis, etc.), which are central to its identity. The overall trend of a pitch contour (e.g. declining) is the result of differences in the scaling factors. Ladd (2008a) highlights that F0 tends to decline over the course of phrases and utterances, both in tone and intonation languages. In questions, this may be suspended or reversed. There are unresolved questions about the representation of this declining F0 over an utterance. In Pierrehumbert (1980), declination was said to be intentionally controlled, and that it should be accounted for using *downstep*, marked (!): the stepwise lowering of pitch (or the tonal space) at specific pitch accents (Ladd, 2008a: 76). Thus, in a declining contour with two pitch accents, the second pitch accent would be treated as "downstepped" H*L !H*L. Ladd (2008a) considers whether it is appropriate to model a downward trend phonologically in the tonal string. He cites the example of higher overall pitch in yes-no questions found in many languages as compared with corresponding lower pitch in statements. However, Ladd proposes that this difference is "arguably paralinguistic and hence … an extrinsic scaling factor" which is the result of a modification of the tonal space itself (ibid. 210). He suggests that the height of the individual tones should not involve the specification of a particular level for a string of tones, but should be described as an extrinsic scaling factor and a modification of the tonal space itself. Ladd notes that the "treatment of pitch range in AM intonational phonology is by no means settled" (ibid.: 210).

Phrasing and structure

An important consideration when discussing the AM approach is the breaking down of continuous speech into smaller units. The *intonation phrase* introduced in Pierrehumbert (1980) contains at least one pitch accent. The Pierrehumbert (1980) analysis contains *only* this one level of phrasing. However in subsequent analyses (Beckman and Pierrehumbert, 1986 and Pierrehumbert and Beckman, 1988) a second level of phrasing is introduced: the intermediate phrase (ip). One or more ips can make up an IP. This second level is delimited by a final *phrase accent,* occurring at the end of the ip, preceding the boundary tone occurring IP finally. Thus, in English, the last pitch accent of each phrase is followed by "two extra tones which characterise the intonation at the end of the phrase"

(Pierrehumbert, 1980: 236). The motivation for this, according to Ladd (2008a) is that the rising-falling-rising nuclear accent contour in English can be analysed as L+H* (an L leading the starred H) or L*+H (a H trailing the starred L) with the fall as a reflex of an L phrase accent (the final rise is a H% boundary tone). Thus, the rising-falling-rising pattern in English would be transcribed as L+H* L- H%. However, there has been some criticism of the existence of edge tones (e.g. Gussenhoven, 2005) which will be discussed in more detail in Section 3 and further in Chapter Five.

In Pierrehumbert's (1980) thesis, she proposed only one initial boundary tone: marked %H that was used to distinguish a marked higher pitch at the utterance onset. The final boundary tones were binary: H% or L%. The H% represented a final rise, while the L% represented the absence of a rise. However, subsequent analyses proposed by Ladd (1983) suggested that sustained pitch should be marked by no boundary tone. This has been adopted by several transcription models, notably Grabe (1998) and the subsequent work in IViE (Grabe, 2004) where a level final boundary tone is marked as 0% or %. For more detail on IViE and other transcription models, see Section 3 below.

3 Autosegmental-metrical transcription models

This section will provide an overview of three AM transcription models: ToBI (Tones and Break Indices) (Silverman et al, 1992; Pitrelli, Beckman and Hirschberg, 1994: Beckman and Ayers Elam, 1997), ToDI (Transcription of Dutch Intonation) developed primarily by Gussenhoven and colleagues (Gussenhoven, 2002; 2005) for Dutch and IViE (Intonational Variation in English), a labelling guide developed as part of a project of the same name (Grabe, 2001, 2005; Grabe et al., 1998, 2001). All three systems aim to model intonation by providing a set of phonological labels that correspond to intonational events, proposing important inferences about the kinds of structures present in the language. All three models are based on AM principles, but differ to account for differences in the varieties under investigation and in their different assumptions about the types of structures that are necessary to model intonation (as will be explained below).

ToBI

The ToBI (Beckman and Hirschberg, 1994) system was established as a formal framework based on the work of Pierrehumbert (1980) and Beckman and Pierrehumbert (1986). It built on this body of work by providing a minimalistic labelling system in order to transcribe the intonation and prosodic structure of speech. ToBI was developed as the original annotation system for Mainstream American English (MAE).

In their 2005 paper summarising the original ToBI system, Beckman, Hirschberg and Shattuck-Hufnagel highlight some of the main features of the original ToBI and the development of the ToBI framework since that point. A full MAE_ToBI record has six parts: an *Audio* recording of the utterance, an electronic or paper *Record of the F0*, a *Tones* tier holding the autosegmental transcription of the intonation contour, a *Words* tier containing an orthographic transcription of each word in the utterance, *Break-indices* (BI): a numerical index of the perceived degree of juncture after each orthographic word, and a *Miscellaneous* tier where markers of disfluencies, comments and other miscellaneous events takes place. The *Break index tier* of ToBI is based on the work of Price et al. (1991) who propose the implementation of a number of break indices based on the prosodic dissociation between words in the utterance. The break index tier in ToBI consists of four basic break index values indicating the perceived degree of boundary strength for each word in an utterance:

0 (very close inter-word juncture)
1 (ordinary phrase-internal word end)
3 (intermediate phrase end, with phrase accent)
4 (intonational phrase end, with boundary tone)

(Beckman, Hirschberg and Shattuck-Hufnagel, 2005: 23)

The *Tones* tier is based heavily on the work of Pierrehumbert (1980) and Beckman and Pierrehumbert (1986). It is used for labelling tones and provides "a symbolic transcription of the intonation contour" (Beckman et al., 2005: 20). Within the *tone tier*, tones are defined as being *edge tones* or as being affiliated with *pitch accents*. As with Pierrehumbert (1980), a pitch accent is associated with the segments of the relevant accented syllable whereas an edge tone is associated with the segments at the relevant phrase boundary (Beckman et al., 2005: 15). Within the edge tone category, there are two types: *phrase accents* associated with the right boundary of the intermediate phrase (ip) and *boundary tones* associated with the right boundary of the higher constituent structure: the intonational phrase (IP):

phrase accents:	H- (!H-), L- (obligatorily placed at every BI = 3 and higher)
boundary tones:	H%, L% (obligatory at every BI 4)
	%H (marginal, at beginnings of some IPs after pause)
pitch accents:	L*, H* (!H*), L+H* (L+!H*), L*+H (L*+!H), H+!H*

(Beckman, Hirschberg and Shattuck-Hufnagel, 2005: 23)

As can be seen, these labels take inspiration from Pierrehumbert (1980), and Beckman and Pierrehumbert (1986). MAE_ToBI also implements the notion of downstep in the pitch accents, indicated by the (!).

Beckman and colleagues (2005) point out that the original ToBI system was established for Mainstream American English and the proposed tonal categories were based on a large body of research. They also point out that MAE_ToBI should not be used as a variety-neutral phonetic transcription system: it should not be assumed applicable to other varieties of the same language without first establishing appropriate intonational and prosodic categories for each variety. ToBI-style transcription systems have been established for a number of languages including German, Japanese, Korean, Dutch (see Jun, 2005, for an overview) providing adaptations in order to capture important intonational phenomena that may be different from MAE. However, two other systems (ToDI and IViE) have been developed which differ in their methods of transcription.

ToDI

ToDI (Transcription of Dutch Intonation) was initially developed as a transcription system for Standard Dutch. The ToDI system is worth consideration due to the different underlying assumptions about intonational events as compared with ToBI. The primary purpose of ToDI is to provide transcriptions of speech data “from which subsequently generalisations about accentuation, phrasing and tone choice could be extracted” (Gussenhoven, 2005: 121). Following AM principles, ToDI aims to characterise the intonation of Dutch utterances using a set of H and L tones which can combine into *pitch* *accents* and *edge tones*, which are associated with prominent syllables and prosodic boundaries (as with ToBI and Pierrehumbert (1980)). It is comprised of the following initial and final boundary tones and pitch accents:

Initial boundary tones:	%L	
	%H	
	%HL	
Final boundary tones:	L%	
(optional)	H%	
Pitch accents:	H*	(sustained high pitch)
	L*	(sustained low pitch)
	H*L	(falling pitch)
	L*H	(rising pitch)
	H*!H	(vocative chant)

Gussenhoven (2005: 127)

As can be seen above, ToDI has a number of features in common with ToBI, but it differs in its labelling of intonational events following criticism by Gussenhoven (2005) and his colleagues about aspects of ToBI and Pierrehumbert-style analyses. These are outlined below:

- Single tonally marked phrase

Firstly, ToDI does not distinguish an intermediate phrase (ip) constituent for Dutch. Only one type of edge tone (the boundary tone) is used to mark the beginning and end of the IP. ToDI also omits the labelling of break indices: “prosodic breaks are only included from the tonally marked constituent (the IP) onwards” (Gussenhoven, 2005: 122), i.e. there is no labelling of prosodic breaks for smaller constituents.

- Three-way opposition for boundary tones

ToDI distinguishes three boundary tones (as compared with ToBI’s two) utterance-initially and two optionally in phrase final position. Utterance-initially these are %L (mid or low pitched), %H (marked high pitch) and the rare highly marked falling %HL. There are two final boundary tones (H% and L%), which are optional. Thus, ‘with two tones, this leads to a three-way opposition in the way IPs end’ (Gussenhoven, 2005: 122).

- Lack of leading tones

As discussed in the subsection ‘Phrasing and structure’, the organisation of the tones in pitch accents is also different in ToDI; the system does not permit the labelling of leading tones preceding the starred tones. ToDI adopts only left-headed pitch accents (e.g. L*H or H*L, and never L+H*). Thus, the tone associated analysed as a ‘phrase accent’ in

ToBI is omitted in ToDI. In reapplying this to the English rising-falling-rising nuclear accent contour described by Pierrehumbert's earlier analysis L+H* L- H%, ToDI would represent this as H*L H% (with the preceding L linked to the preceding pitch accent or boundary tone, if it is required to be represented).

- Singleton T* describing level pitch

The H* and L* pitch accents are reserved *only* to describe accented high and low pitch which is maintained until a further tone is transcribed. H*L and L*H are used to represent falling and rising pitch (Gussenhoven, 2005: 126). This aims to tackle a problem which Gussenhoven highlights, namely the difficulty for labellers using the ToBI transcription system to distinguish between H* and H*+L.

Gussenhoven (2005: 142) states that there are two main reasons for proposing a new system for the transcription of Dutch intonation instead of using ToBI. The first is that Dutch has contours that American English does not, and thus a label to describe these contours is lacking in ToBI. The second and perhaps most important is that there are "a number of drawbacks" with ToBI which ToDI avoids (Gussenhoven, 2005: 142). These drawbacks will be considered in detail in Chapter 5 of this thesis.

IViE

The IViE project (Intonational Variation in English) was set up to investigate directly comparable experimentally controlled data from several dialects of British English. This project collected a large corpus of recordings from several dialects and was transcribed using a prosodic transcription system. The IViE transcription standard is based on the phonological analyses of British English by Gussenhoven (1984) and Grabe (1998). However, IViE aims to provide directly comparable transcriptions of *several* varieties, unlike the original ToBI system, which was developed for MAE. As such, the system incorporates a number of changes in order to achieve the cross-dialectal comparison (Grabe et al. 1998; Fletcher et al. 2005).

- Tiers

An IViE transcription contains five tiers: *the orthographic tier, the rhythmic tier, the pitch movement tier, the phonological tier* and *the miscellaneous tier*. IViE, like ToDI, does not have a break index tier, "because the system does not deal with different degrees of disassociation between words within intonation phrases or different degrees of boundary strength" (Fletcher et al. 2005: 403). IViE distinguishes two 'new' tiers: the *rhythmic tier* and the *pitch movement tier* in an attempt to increase the transparency and replicability of transcriptions on the phonological tone tier (ibid.: 403). That is, the tiers break down the process of highlighting rhythmically prominent syllables and identifying the associated pitch. The *rhythmic tier* is used to identify the rhythmically prominent syllables to which the pitch movements on the phonological tier are anchored. The rhythmically prominent stressed vowel is labelled with a "P" for prominence. Then, rhythmically prominent syllables that are both stressed *and* accented ("that is, associated with pitch movement" (ibid. 403)) are identified and by assigning labels on the *pitch movement tier*. This tier has "heuristic rather than linguistic status; it allows labellers to make a record of the impression of a particular pitch movement which, combined with other information leads them to assign phonological labels to a contour at a later stage" (ibid. 403).

- Tonal inventory

Also, IViE makes changes to the tonal inventory as compared with ToBI. As with ToDI, all pitch accents are left-headed: they begin with a symbol (H or L) to indicate the tone that is associated with the stressed syllable. A further H or L optionally follows this if there is movement in the subsequent unaccented syllables (a rise or fall). Furthermore, only one phrase final edge tone is identified: the boundary tone. Unlike ToBI (but like ToDI), there are three options (rather than two) for the boundary tone: high (H%), no pitch movement (%) or low (L%). These are labelled on the *phonological tier:*

Boundary tones:

Phrase-initial	Phrase-final	Description
%H	H%	High target
	%	No pitch movement at boundary
%L	L%	Low target

Pitch accents:

Pitch accent	Description
H*L	High target on prominent syllable followed by low target before the next accented syllable
H*	High target
L*H	Low target on prominent syllable followed by high target before the next accented syllable
L*	Low target

(Grabe, 2001)

This section has outlined the basic features of the three transcription systems that are used widely in intonation research. However, a number of criticisms have arisen in the literature related to the use of transcription systems in general, which will be addressed in Chapter 5 of this thesis.

4 Phonetic realisation

*A*coustic phonetic data formed the basis for the autosegmental-metrical argument that intonational *tones* are the building blocks of intonation, rather than the 'rises' and 'falls' of previous intonational analyses. The resulting autosegmental principles see a pitch contour realised as a string of tones at two levels (High and Low), which are associated with the segmental string. The phonetic reflex of these tones is "generally conceived as some sort of *tonal target*" (Ladd, 2008a: 169, emphasis added). A great deal of instrumental work has been undertaken on the phonetic realisation of tonal targets.

Tonal targets are realised in two phonetic dimensions: variation in pitch level referred to as *scaling* and variation in temporal coordination with the consonants and vowels in the segmental string, referred to as *alignment* (Ladd, 2008a.: 169). Previous instrumental phonetic research has shown that scaling and alignment of tonal targets are very regular and this can be predicted by a number of variables. This thesis, in investigating the intonation system of Anglesey Welsh will focus on two variables which are known to affect the scaling and alignment of targets cross-linguistically. These are:

- interrogativity and sentence mode
- phonetic pressure as a result of reduction of syllabic material on which the intonation contour is realised.

Research into the effects of these two variables can provide information about the phonological structure of the tones, indicating where important relationships may occur.

The section below discusses some of the issues associated with the phonetic investigation of scaling and alignment but most of the discussion of the intonational encoding of interrogativity and phonetic adjustments due to temporal constraints will be reserved for Chapters 3 (scaling) and 4 (alignment).

Much AM phonetic research has found that there are extremely consistent and predictable alignment patterns to tonal targets. For example, in Greek it has been found that the L in prenuclear accents is aligned with the beginning of the accented syllable and the H is aligned near the beginning of the unstressed syllable immediately following the accented syllable (Arvaniti and Ladd, 1995; Arvaniti, Ladd and Mennen, 1998), regardless of the duration of the accented syllable. This lawful alignment has come to be known as "segmental anchoring" and has been found by researchers for a number of other languages, e.g. Ladd et al. (1999) for English, Prieto (2005) for Catalan and Ladd, Mennen and Schepman (2000) for Dutch.

As well as research showing that "both scaling and alignment are highly lawful", AM phonetic research has shown that the phonetic realisation can also be "systematically influenced by a range of phonetic and phonological effects" (Ladd, 2008a: 169). A great deal of research has focussed on the phonetic realisation under different prosodic and segmental contexts (e.g. Silverman and Pierrehumbert, 1990; Caspers and van Heuven, 1993; Prieto et al., 1995; Grabe, 1998; Ladd et al., 1999; Ladd, Mennen and Schepman, 2000; Schepman, Lickley and Ladd, 2006; Arvaniti, Ladd and Mennen, 2006; Dalton and Ní Chasaide, 2007). It has been found that "the alignment of turning points can be predictably variable as well as predictably stable" (Ladd, 2008a: 173). For example, the prosodic context (e.g. the proximity of other pitch accents or prosodic boundaries) can cause adjustments in the scaling and alignment of the tonal targets. Much of the discussion of these adjustments is reserved for Chapters 3 and 4, but two effects; *compression* and *truncation,* deserve consideration here.

As discussed above, there is predictable variability in the scaling and alignment of tonal targets. However, different languages have been found to have different ways of dealing with phonetic pressure. The first, *compression,* involves the full realisation of all of the targets in the available time (through increased F0 rate of change), while *truncation* is the reduction of one or more targets (there is no adjustment in the rate of fall or rise in the contour) (Nolan, 2007: 450). Grabe (1998) provides a schematic representation of fundamental frequency compression and truncation of an L tonal target in words of different length, as shown in Figure 1.

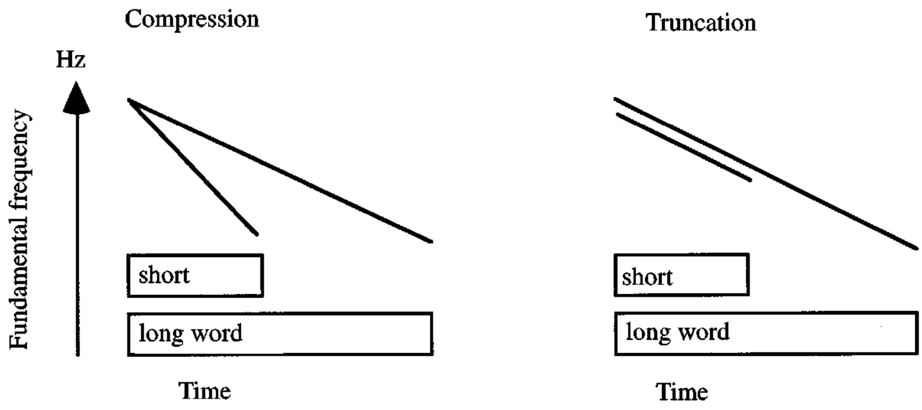


Figure 1: Schematic representation of fundamental frequency compression (left) and truncation (right) on words of different length from Grabe (1998: 131).

It has been found that English and Greek in general prefer compression in nuclear accents while Hungarian and Palermo Italian prefer truncation in order to deal with phonetic pressure (Ladd, 2008a: 182). Other than utterance final nuclear L or H targets, other targets earlier in the segmental string may also be *compressed* or *undershot*. The compression in non-final targets results in the H peaks (or L valleys) being realised earlier or later depending on their position in the utterance. For example, H peaks may be aligned relatively earlier with upcoming pressure, or later with preceding pressure from prosodic events (pitch accents or prosodic boundaries). However, some languages prefer to *undershoot* these H or L targets (e.g. Arvaniti et al. 1998; 2006; Arvaniti and Ladd, 2009; Prieto, 2005). Rather than being re-aligned, they may be re-scaled and realised less high (in the case of H peaks) or less low (in the case of L valleys) in conditions of increased phonetic pressure. The issue of truncation, compression and undershoot and whether they feature in Anglesey Welsh will be investigated as part of Chapter 3 and 4.

Not only can tonal targets be affected by the phonetic or phonological structure of an utterance, but the grammatical function of an utterance has also been shown to affect the scaling and alignment of tonal targets. For example, pitch peaks have been found to be scaled higher and/or later in questions than statements and questions are often found to have a wider pitch range than statements in several languages (D'Imperio and House, 1997; D'Imperio, 2000; Haan, 2002; Grabe, 2004; Prieto, 2005; Makarova, 2007; D'Imperio et al., 2007). Hirst and Di Cristo (1998) note that every language displays an intonational system of some sort and very often two pitch patterns are evident in intonation languages: low i.e. falling pitch patterns and raised or rising pitch patterns. The latter is usually used to indicate questions with the former indicating statements. Some researchers argue that there may be a universal basis to high or rising question intonation. Bolinger (1986) proposes that there is a biological gestural basis: the rising and falling pitch movements are similar to the up and down movement of our hands, shoulders, eyebrows etc. Both intonation and gesture are used to express the speaker's emotional state: rising with tension and lowering with relaxation. Where information is required (for example, in a question), the questioner feels tense; raising their voice to indicate that they require a reply. Ohala (1994) also suggests that high and rising question pitch in some way is a universal feature which is an example of sound symbolism: i.e. the relationship between high pitch and its interrogative meaning is not arbitrary. He suggests that high and rising question pitch is related to systems of animal communication: "the sounds made by a confident aggressor are typically rough and have a low F0; submissive or non-threatening individuals' cries… have a high F0" (ibid: 329). Therefore, the meaning conveyed by the aggressor indicates dominance and confidence while high/rising pitch signals subordination or dependence. Ohala (ibid: 330) names this cross-species F0-function correlation "the frequency code". He suggests this pre-linguistic code is what causes the cross-linguistic ("universal") features of high/rising pitch found in questions. The questioner in human interaction appeals to the addressee for help: the questioner is subordinate, while the person making a statement is self-sufficient from an information standpoint.

This Universalist view has been met with some scepticism. Ladd (2008a) argues that there are several problems with referring to these universal tendencies. Firstly, he argues question contours in different languages and different dialects have different overall shapes (or tunes), which show that high pitch intonation cannot be a general universal. Following on from this, Ladd argues that the universal observations are problematic because they are based on a "Eurocentric" sample. There are several exceptions to the falling declarative and rising question pattern, for example a rising statement pattern is found in Belfast English declaratives and falling questions are found in Bengali (Gussenhoven, 2004: 54) and Greek (Arvaniti et al, 2006). Finally, Ladd argues that many universal observations are vague, referring to a very general "high or rising question pitch", meaning that it is difficult to test empirically. Ladd proposes that without a widely used approach to intonation (such as the AM approach), it is difficult to compare intonation across languages and make generalisations about the universal nature of intonation.

Nevertheless, there are several features associated with high or rising pitch that often have been found cross-linguistically to occur in questions. These are:

- Final rising pitch
- Higher onset
- Raised nuclear accent peak
- Raised register level
- Suspension of downtrends

These features have been found to be common of question intonation in a number of languages, although the presence of a feature of combination of features is dependent on the language and variety.

Following on from this, Haan (2002) proposed a hypothesis that there may be a trade-off between lexical or syntactic markers of interrogativity in a question and the presence of intonational markers of interrogativity. It is known that many languages distinguish grammatical meaning using lexico/morpho-syntactic marking through the use of particles, words or changes to word order. For example, many languages (e.g. English, Dutch) distinguish questions from statements by using segmental morphemes (e.g. question particles) or inversion (Ladd, 2008a). However, in many languages this distinction is conveyed only intonationally (Ladd, 2008a). In languages such as Greek, Spanish and Italian, yes-no questions are lexico-syntactically identical to their statement counterparts so speakers must employ another method to mark questions (i.e. there must be some way that the question function is marked phonetically to the listener). Dryer (2013) in his survey of 955 languages notes that 173 of them (18%) mark questions only intonationally without the presence of lexical, morphological or syntactic markers of interrogativity (although it is noted that the actual percentage may be higher due to underrepresentation in the study). Haan predicted that the features described above (final rise, higher onset, raised nuclear accent peak, raised register level and suspension of downtrends) would be maximally present in *declarative* questions in Dutch, which are lexico-syntactically unmarked for interrogativity. She hypothesised that intonational marking would be present to a lesser extent in questions which featured syntactic marking through inversion (in Dutch, yes-no questions) and least in questions with a question word *and* inversion (wh-questions). She did indeed find that the less marked questions displayed more intonational marking than the statements and that this marking occurred in different degrees.

Welsh is a particularly interesting case in this regard. Syntactically questions are identical to statements as there is no subject-verb inversion (contrary to for example, English and Dutch). As can be seen in Table 1 below, the wh-questions are *lexically* marked in Welsh with the addition of a question word and the remaining information as a relative clause (after Awbery, 2009). However, yes-no questions may be lexically marked with a different form of the main *to be* verb. Declarative questions, as in Dutch and English are lexico-syntactically unmarked.

Table 1 Status of question types in Welsh and their lexico-syntactic marking compared with statement

Sentence type	Example	Difference from statement
Statement	Mae Manon yn licio mafon. be.3S.PRES Manon PRT like.NONFIN raspberries 'Manon likes rasberries.'	
Yes-No question	Ydy Manon yn licio mafon? be.3S.PRES Manon PRT like.NONFIN raspberries 'Does Manon like raspberries?'	Different form of 'be' verb
wh-Question	Pam mae Manon yn licio mafon? why be.3S.PRES Manon PRT like.NONFIN raspberries 'Why does Manon like rasberries?'	Addition of question word, statement as a relative clause
Declarative question	Mae Manon yn licio mafon? be.3S.PRES Manon PRT like.NONFIN raspberries 'Manon likes raspberries?'	Not syntactically different

It might therefore be expected that the pitch peaks of the above sentence types may be scaled and aligned in a gradable way as a function of the lexico-syntactic marking available to the speaker. For example, higher and later accent peaks may be maximally present in questions that are not otherwise marked for interrogativity (DQ), less present in questions with a differing verb (YQ), and minimally present in questions with an additional question word (WQ). This question will form a subordinate theme to this thesis that will be investigated in Chapters 3 and 4.

Further background and exploration of the studies relating to the effects of encoding interrogativity and phonetic pressure (reduced 'space' to realise a pitch contour) will be provided in Chapters 3 and 4.

Thesis aims

This thesis aims to follow the tradition of AM intonational phonology by providing an analysis of the intonation system in Anglesey Welsh along two dimensions: with reference to the phonetic realisation of the structural components and with reference to its phonological structure. The current chapter has provided the first introductory chapter, by giving the background and theoretical considerations surrounding the study of intonation. Chapter 2 will form the second introductory chapter and introduce the background to the Welsh language and previous studies on its prosodic structure. Chapters 3 and 4 will concentrate on the phonetic realisation of the structural elements that make up intonation by looking at their *scaling* and *alignment* and how they may be used to indicate grammatical function. Chapter 5 will use the data presented in Chapters 3 and 4 to form the basis of a discussion and exploration of the phonological structure of intonational components in Anglesey Welsh. Finally, Chapter 6 provides a general summary and discussion and concludes the thesis.

Chapter Two

Welsh

1 Background

Welsh (Cymraeg) is a member of the Brythonic branch of Celtic languages. It is spoken primarily in Wales as well as in a small community in a Welsh colony in Patagonia, Argentina (Williams, 2009). There has been a substantial increase in the number of speakers since the 1980s (Crystal, 1998: 305) although the latest census reports a slight drop in the proportion of speakers (from 20.8% in 2001 to 19% in 2011; ONS, 2013). 562,016 speakers currently speak the Welsh language across the whole of Wales (ONS, 2013). However in Anglesey and Gwynedd in North West Wales (the area under investigation), this number is 38,568 and 77,000 (57.2% and 65.4% of the population respectively). The specific area under investigation is the Town of Menai Bridge on the south coast of the Isle of Anglesey. Menai Bridge (Porthaethwy) is split into two electoral wards (Cadnant and Tysilio) in census data. When combining these wards to include the whole of the town, 1790 people reported speaking Welsh out of a total population of 3263, that is 54.9%.

The Celts were the first Indo-European people to spread across Europe and the Celtic languages have been spoken in the British Isles since before Roman times. Roman invaders in the 1st Century and Anglo-Saxon invaders in the 5th Century pushed the British Celts northward and westward causing the dialects to become distinct (Crystal, 1998: 304). Until the 16th century, Welsh speakers were mostly monolingual but the Acts of Union with England in 1536 resulted in the curtailment of the Welsh (and Welsh medium) legal system in place of the English system. This consequently led to an increased amount of Welsh-English bilingual speakers (Coupland, 1990). The Acts of Union is cited as one of the milestones in the erosion of the Welsh language (Owen Jones, 1993). In 1847 the *Report of the commissioners of enquiry into the state of education in Wales* was published. This report concluded that schooling in Wales was inadequate and that there was a general lack of education of the Welsh people. They cited this as the cause of the social problems in Wales. The report caused great agitation in Wales mostly for the fact that Welsh was equated with poverty, ignorance and low status (Owen Jones, 1993). The report stating that “the Welsh language is a vast drawback to Wales and a manifold barrier to the moral progress and commercial prosperity of the people. Because of their language the mass of the Welsh people are inferior to the English in every branch of practical knowledge and skill” (Report of the Royal Commission, 1847: Part II: 66, in Owen Jones, 1993). In the subsequent overhaul of education and establishment of a new elementary system in Wales, the Welsh language was widely ignored. Children were punished for speaking Welsh at school under the new system. This inevitably contributed to a decline in the number of Welsh spoken in the community towards the end of the 1800s. However, several measures to promote a revival in the last century have led to Welsh being represented in legal settings, education and the media. The Welsh Language Act of 1967 returned rights to the Welsh language in court proceedings and aimed “to make further provision with respect to the Welsh language” (Welsh Language Act 1967, 1). However, Welsh was not given “equal” status until the Welsh Language Act of 1993 which stated that “so far as is both appropriate in the circumstances and reasonably practicable, to the principle that in the conduct of public business and the administration of justice in Wales the English and Welsh languages should be treated on a basis of equality.” (Welsh Language Act, 1993: 3).

In Wales today there is also a widespread presence of Welsh in the media with a Welsh language television channel (S4C), Welsh language radio stations (e.g. BBC Cymru) and online news websites. Furthermore, Welsh and bilingual medium primary and secondary schools are found all over Wales. The first Welsh-medium primary school opened in 1947 and by 2009, 29% of primary schools were Welsh medium (Welsh Assembly Government, 2010). The first Welsh-medium secondary school opened in 1956 and by 2009 25% of secondary schools “provide(d) Welsh-medium lessons in more than half the curriculum subjects” (Welsh Assembly Government, 2010). In 2010 the Welsh Government released their updated *Welsh-medium Education Strategy* that sets out “the ambition of the Welsh Assembly Government for a country where Welsh-medium education and training are integral parts of the education infrastructure” (Welsh Assembly Government, 2010: 4). The “vision of continuing growth of Welsh-medium education in response to demand and provision of linguistic continuity is a long-term agenda” as well as to promote bilingualism for the benefit of the population (Welsh Assembly Government, 2010: 10).

Variation

There is widespread variation in the regional Welsh spoken. Welsh is comprised of a number of dialects, the phonetics of which have never been investigated at a cross-dialectal level. However Hannahs (2013: 11) points out that Welsh is typically divided into two large dialect areas, northern Welsh or North Walian, and southern Welsh or South Walian. Dialectal variation with regards to lexical items and syntactic structure has been fairly well documented for Welsh: *The Welsh Dialect Survey* by Thomas (2000) provides a good overview of lexical variation and isoglosses, *Cymraeg, Cymrâg, Cymrêg… Cyflwyno'r Tafodiethoedd* by Thomas and Thomas (1989) provides a good introduction to the general dialect areas of Welsh and Borsley, Tallerman and Willis (2007), provide a good overview of syntactic variation in Welsh dialects in *The Syntax of Welsh*. As this thesis focuses on the suprasegmental characteristics of the language, further discussion of variation in lexical and syntactic structure is not undertaken here. A broad outline of syntactic structures relevant to the thesis will be outlined below in Section 2, with further discussion of studies of suprasegmental phenomena in Section 3 below.

2 Welsh syntactic structure

Welsh has a relatively rigid word order in regular declarative statements (Watkins, 2002). An inflected verb is found in sentence initial position, followed by a subject and then an object (with further prepositional phrases or adverbs following these) as can be seen in Example a). In spoken northern Welsh, the *mi* particle (indicating positive, declarative embedded clauses) may be deleted (Morris-Jones, 2010: 3).

a) (Mi) welodd Manon Wil.
(PRT) see.3S.PAST Manon Wil.
'Manon saw Wil.'

However, not all constructions follow this VSO word pattern. The periphrastic construction is common in spoken Welsh and an inflected form of *bod* 'to be' or *gwneud* 'to do' is focussed initially. This construction is used to display a range of tense and aspect meanings "particularly in relatively informal registers" (Watkins, 2002: 401). The inflected verb is then followed by a subject, aspect particle, uninflected verb form and then the object as illustrated in b) below.

b) (Mi) wnaeth Manon weld Wil.
(PRT) do.3S.PAST Manon see.NONFIN Wil.
'Manon saw (did see) Wil'

Adjectival or nominal complements can appear following the subject or object with the particle *yn* marking progressive aspect, as in c) or *wedi* marking perfective aspect (Morris-Jones, 2010: 305).

c) Roedd Manon yn flin.
be.3S.PAST Manon PRT angry.
'Manon was angry'

Most importantly for this study, word order does not differ between statement and the corresponding yes-no questions. In formal written Welsh, yes-no polar questions are marked with a question particle such as *a, ai, oni, onid* as in:

d) Ai welodd Manon Wil?
PRT see.3S.PAST Manon Wil.
'Did Manon see Wil?'

However, in spoken Welsh, the question particle has disappeared, with Watkins (1961: 30) noting that "y dôn yw'r unig elfen wahaniaethol" *the tone is the only differentiating element* between the statement and the question in Welsh. The yes-no questions *may* be marked by a different form of the main verb initially (as in e) below) but this happens only with forms of the verb *to be*. In other verb initial constructions (f) and the periphrastic constructions (g), the verbs in the questions are identical to those produced in the statements and where both the *mi* particle and the *ai* question particle disappear in spoken Welsh, there is no difference between the statement and question.

e)	Mae Manon yn flin. be.3S.PRES Manon prt angry 'Manon is angry.'	Ydy Manon yn flin? be.3S.PRES Manon prt angry 'Is Manon angry?'
f)	Welodd Manon Wil. see.3S.PAST Manon Wil. 'Manon saw Wil.	Welodd Manon Wil? see.3S.PAST Manon Wil. 'Did Manon see Wil?'

g) Wnaeth Manon weld Wil.
do.3S.PAST Manon see.NONFIN Wil.
'Manon saw Wil?'

Wnaeth Manon weld Wil?
do.3S.PAST Manon see.NONFIN Wil.
'Did Manon see Wil?'

Wh- questions have a wh-pronoun in sentence initial position and the rest of the question appears with a relative clause as in h) (VSO) and i) (periphrastic) (Awbery, 2009).

h) Lle welodd Manon Wil?
where see.3S.PAST Manon Wil.
'Where did Manon see Wil?'

i) Lle wnaeth Manon weld Wil?
Where do.3S.PAST Manon see.NONFIN Wil.
'Where did Manon see Wil?'

These are the main syntactic patterns for Welsh that will be elicited to form the dataset to be analysed in this thesis. In Chapter 3, Section 3, the design of materials used in this thesis will be reported in more detail.

3 Research on Welsh prosody

Whist segmental aspects of the Welsh language have been fairly well documented, it is known that the suprasegmental characteristics of the language have been vastly under described (Ball and Williams, 2001; 163). This section will focus on presenting some of the albeit limited previous work on the suprasegmental aspects of Welsh including stress, intonation and a brief discussion of prosodic constituency. The aim of this section is to highlight gaps in out knowledge about Welsh intonation and its structure, especially in Anglesey Welsh.

3.1 Stress

The stress pattern of Welsh lexical items is highly regular, with the primary stress in polysyllabic words occurring predominantly on the penultimate syllable (the penult). There are some cases of irregular stress in Welsh. The most common pattern involves the placement of primary stress on the final syllable in polysyllabic words (the ultima) and a less common pattern where primary stress occurs on the antepenultimate syllable, mainly in loanwords from English (Morris-Jones, 1913; Watkins, 1961; Williams, 1989; Ball and Williams; 2001).

The acoustic correlates of lexical stress in most European languages (e.g. French, German, English) include a stressed syllable that features higher F0 on the stressed vowel, greater duration and/or loudness of the stressed vowel and a more peripheral realisation of the vowel (Ball and Williams, 2001: 169). However, Williams (1985: 381) claims that the acoustic cues of stress in Welsh appears to not be "directly related to the usual acoustic cues of F0, intensity and duration of the stressed vowel". Several other researchers have made similar observations related to the realisation of stress in Welsh (e.g. Fynes-Clinton, 1913; Jones, 1949; Watkins, 1961; Thomas; 1967 and Oftedal, 1969). For example, in polysyllabic words, it has been noted that penultimate stressed syllables may not be pitch prominent when compared to the ultima. Furthermore, the stressed syllable may not feature greater amplitude or longer duration than the ultima. The following paragraphs note some of the previous observations and instrumental studies of lexical stress in Welsh.

Jones (1949) and Watkins (1961) were among the first to propose the feature of higher pitch on the ultima: "mewn gair deusill mae'r dôn uchaf ar y sillaf olaf…" *In a disyllabic word the highest tone is on the last syllable* (Watkins, 1961: 29). Neither Jones nor Watkins specify a specific variety of Welsh in their discussion of this feature. Jones suggests that the penultimate and final syllables are fairly equal in prominence (the difference "is small, much less than that between the penultimate and the preceding syllables in a polysyllabic word" (ibid.: 63). Oftedal (1969) in a study of Meirionethshire (mid-western) Welsh, also notes high pitch on the ultima, realised as a peak "which is placed higher on the musical scale than any point of the preceding syllable" (ibid. 122). Oftedal proposes that there is a link between this distinctive pitch pattern and stress, very similar to that observed in Scandinavian tone distinctions (e.g. East Swedish and Southwest and East Norwegian).

The Scandinavian languages have a tone contrast often referred to as Accent 1 and Accent 2 (Bruce, 1977). Oftedal summarises that "in these dialects, the second syllable of sequences with Accent 2 (a) reaches a higher pitch than the preceding syllable and (b) carries an amount of stress which often equals and occasionally surpasses the stress of the preceding syllable traditionally called 'stressed'" (p. 123). In contrast, the second syllable of sequences with Accent 1 in these dialects is realized at a lower pitch than the first syllable. Oftedal proposes that this distinction between Accent 1 and Accent 2 may well account for the different patterns found in Welsh to distinguish between different constructions such as *ein cwm ni* (our valley) and *ein cwmni* (our company):

	Accent 1	Accent 2
j)	ein cwm ni	ein cwmni
	POSS.3PL valley PRON.3PL	POSS.3PL company
	our valley	our company

Oftedal proposes that the feature of higher pitch on the ultima can be used to distinguish between the possessive construction for 'valley' (featuring the *ni* pronoun) and the possessive construction for 'company'. Oftedal's paper is based on observational fieldnotes and as far as is known, has not been tested instrumentally. Nevertheless, this paper highlights the perceptual importance of the high pitch on the ultima, which has been noted by many.

Instrumental studies on Welsh stress

In an attempt to investigate features of stress production (and perception) in Welsh, Williams (1985, 1986 and 1989) undertook experimental research to investigate the contribution of F0 and segmental duration to stress production and perception. Williams (1989) presented six studies investigating the acoustic correlates of lexical stress in Welsh.

The first used readings of words in citation form by a "male native (South) Welsh speaker" (ibid. 27). The read words were polysyllabic words, which were either isolated or embedded in utterance final position in a carrier sentence. Measurements were taken of the duration of the stressed and unstressed vowels in these words. Subsequently, two English speakers (with no knowledge of Welsh) and a single Welsh speaker were asked to judge which syllable was stressed. It was found that the English listeners were more likely to perceive stress on the final syllable, while the Welsh listener was more likely to perceive it on the penultimate syllable. Williams interprets this as evidence that English and Welsh listeners use different prosodic cues for stress. According to Williams, English listeners followed the acoustic cues for English and located the stress on syllables that had one or more of the following cues on the vowel: F0 change, greater amplitude and longer duration. The Welsh speaker, on the other hand, perceived the stress on syllables that had shorter vowel duration, lower vowel amplitude and little F0 change. Williams concludes that the "usual reliable cues to stress in English and other languages (high F0, high amplitude) are not at all reliable in the case of Welsh" (ibid.: 76). However, her conclusion that there must be different prosodic cues for stress in English and Welsh is inferred from the perception results that the English speakers perceived stress where certain features were more common (F0 change, greater amplitude, longer duration) and the Welsh speakers perceived stress where other features were common (shorter vowel duration, lower vowel amplitude and little F0 change). As non-native listeners of Welsh, the English speakers were forced to decide which of two syllables was stressed without knowledge of the language or the inherent features of segments in the language. The English listeners would not have known whether differences between syllables were due to prosodic factors such as stress or phrasal position, or whether they were due to intrinsic features of the vowels or consonants in that position. The stimuli were also not well controlled, they were polysyllabic words produced in isolation or produced embedded in a carrier sentence in utterance final position. The stimuli were then extracted and presented to the listeners in isolation. The effects of the prosodic position (e.g. utterance finality) and the environment (isolated/ within carrier sentence) were not taken into account in the analysis. The perception of stress on the final syllable may be an artefact of the segmental duration differences due to phrase-final lengthening. Williams' findings must be viewed tentatively due to the flaws in this experiment namely to do with the lack of control and listener numbers (only two English and one Welsh listener were used for the stress judgements).

In a second study of spontaneous speech (produced by several Welsh speakers at the National Eisteddfod festival), Williams extracted words from the uncontrolled speech and played them to a single Welsh speaker (the same listener as above). Williams found that the features judged as stressed by a Welsh speaker were less clear-cut than in her first study. Williams found that the only feature that was consistently present in the syllable judged as stressed by the Welsh speaker was shorter duration of the vowel. However, the recordings for this experiment were reported to be poor, and Williams suggests that this could have been one of the main reasons for the lack of other cues in the in the data set. An additional problem of the study is that by using the uncontrolled speech, Williams had little control over the prosodic environments and the positions in which the stressed and unstressed vowels within utterances. In fact, her data show that her stressed vowels were always penultimate and these were compared to unstressed syllables in word-final position. It is known that vowels are lengthened in word-final (and utterance-final) position (Lehiste, 1972) and it may well be that the shorter than expected duration of the stressed compared to the unstressed vowel can be explained by the effect of final lengthening. This could have been investigated or accommodated for by providing a more in-depth and controlled breakdown of the data for analysis, or perhaps comparing the penultimate stressed vowels to vowels in unstressed syllables in non word-final position (e.g. antepenultimate syllables).

In a third study Williams (1989) reused the unrehearsed speech and stress judgements from the second study and re-analysed them with reference to the rhythmic phenomena above the syllable: the foot duration. Williams categorised the foot measurements following two different hypotheses stemming from the differences in the identification of the stressed by the Welsh and English speakers in the first study. The feet were measured from "stressed vowel" to the following "stressed vowel". For the Welsh speakers' foot, this corresponded from penultimate syllable to penultimate syllable while the English speakers' foot was measured from final syllable to final syllable. Williams claimed that the rhythm appears to be the foundation of stress in Welsh: the length of the Welsh speakers' foot tended to be more equal in length than the English speakers' foot in terms of the number of syllables in the foot. Thus, Williams proposed that the stressed penult "retains its status of "stressed" not by virtue of any acoustic prominence… but because of its function as the keystone of the rhythmic unit" (ibid. 77).

In a fourth study designed to further test the above findings, Williams elicited a list of simple Welsh sentences from the same male speaker as in the first study. She manipulated the length of the stimuli sentences by adding more lexical items and morphemes, thus increasing the number of syllables in each foot:

Mae'r gôt ar fwrdd mewn tŷ. → 6 syllables
'The coat is on a table in a house'
Mae'r gôt ar y bwrdd mewn tŷ. → 7 syllables
'The coat is on the table in a house'
Mae'r cotiau ar y bwrdd mewn tŷ. → 8 syllables
'The coats are on the table in a house'
etc. Williams (1989: 40)

A single Welsh listener made stress judgments. The results for this study supported the findings of study 3: there was a tendency for isochrony in Welsh if feet were measured from penult to penult rather than from final syllable to final syllable. However, Williams found that the results showed the greatest effect (i.e. were most significant) if the rhythmic feet were counted from stressed vowel to stressed vowel than from the consonantal onset of the stressed syllable to the following consonantal onset of the stressed syllable. Nevertheless, she argued that the findings appear to show that there is a rhythmic basis for stress in Welsh.

In her final study, Williams investigated other segmental features of the stressed syllables in order to investigate whether concentrating only on the vowels in studies 1 and 2 had overlooked any further indicators of stress placement in Welsh. Williams collected a list of 32 isolated regularly stressed Welsh disyllables with medial voiceless stops recorded by the same Welsh speaker used for the other studies. Williams took measurements of the consonants and vowels in the words. Her main result showed that the post-stress consonant was significantly longer than the consonant after the final syllable (169 ms : 109 ms, $p < 0.01$). She also found that the stressed vowel was significantly shorter than the unstressed vowel (for phonologically short vowels).

On the basis of these findings, Williams' (1989) claims that there is a rhythmic *and* durational basis for stress in Welsh. She proposes that stress in Welsh is related to rhythmic organization manifested in the preference for isochrony in foot length and durational cues manifested in the preference for "shorter duration of the stressed vowel and longer duration of its following consonant" (ibid. 78). However, as has been shown throughout, there were several issues with the study. Importantly, much of the production data was collected from just one male speaker of Welsh from South Wales for whom we very little information about linguistic background is provided. The same is the case for the speakers recorded at the National Eisteddfod festival. The recordings at the Eisteddfod were also reported to be of poor quality yet Williams still bases two of her studies on this data.

There was an overall lack of control in the experiments presented in the studies, the intonational patterns varied in the first study (some words were elicited in isolation and others were elicited in carrier sentences). The intonational or rhythmic pattern of the carrier sentence could have played a role in the findings of her study and thus more controlled data would be desirable (see Webb, 2011 below). Finally, as pointed out above, the lack of control in her data resulted in comparisons between word-final or utterance-final unstressed vowels compared with penultimate stressed vowels. The effects of final lengthening in the word or larger utterance domain most likely had an effect on the duration of the vowel and thus the stress location for the English listeners who had no knowledge of Welsh words.

In her 1985 paper, Williams followed up her earlier study by manipulating the stress-related minimal pair *ymladd* /ˈəmlað/ "to fight" and *ymlâdd* /əˈmlaːð/ "to tire oneself out" by altering a) the duration of the post-stress nasal consonant /m/ and b) the F0 patterns associated with the words. The pair of words was elicited in carrier sentences from "a female native Welsh speaker" (geographical location not specified). The source words were excised from each of the carrier sentences and the duration of the /m/ segments were manipulated from 13ms to 255ms in steps of 15ms or 11ms. Williams also imposed three pitch patterns: a) a monotone at 280Hz b) a fall/step-down and c) a step up followed by a fall. Ten native Welsh listeners performed stress judgements on this manipulated data.

Williams found that as the /m/ length was increased, the number of *ymlâdd* (final stress) responses decreased: the longer /m/ length was associated with penultimate stress. This effect was greatest in stimuli which had been manipulated from the *ymlâdd* source word which had the monotone pitch assigned to them. However, when *ymladd* (penult stress) was the source word, there was weaker and non-significant correlation between /m/ duration and the number of *ymlâdd* (final stress) responses ($p = 0.0577$).

The effect of the F0 patterns could also be seen in Williams' study. Where the source word was *ymlâdd* (final stress) and a step-down was superimposed, there was a weak correlation between the increased /m/ duration and the number of *ymlâdd* (final stress) responses ($p = 0.0914$). However, where the source word was *ymladd* (penult stress) and a fall was superimposed, there was a higher and significant ($p = 0.0042$) negative correlation between increased /m/ duration and the number of *ymlâdd* (final stress) responses. Williams claims that the F0 pattern plays a role in supporting the perception of *ymlâdd* (final stress). Finally, in the step-up and fall conditions for both source word manipulations, there was a significant negative correlation between the number of perceived *ymlâdd* (final stress) tokens and /m/ length ($p = 0.0166$ for *ymlâdd* (final stress) source word and $p = 0.0442$ for *ymladd* (penult stress) source word).

In fact, the source word from which the manipulations stemmed played a significant role in the categorisation of the stimuli: there were a greater proportion of *ymlâdd* (final stress) responses when *ymlâdd* (final stress) was the source. Williams investigated the properties of the source words and found that the duration of the /a/ vowels differed between *ymladd* (145ms) and *ymlâdd* (201ms), providing a key distinction between the two words.

Williams' (1985) study does highlight that the post stress consonant as well as the superimposed F0 patterns appear to play a role in the indication of stress placement in Welsh. However, the effect of source word highlights one of the main methodological issues with Williams' study. The greater correlation and significance of the source word than any other variable (/m/ duration or F0 pattern) highlights that the analysis was flawed and that there may be underlying factors (other than the vowel length) in the indication of stress in this study (e.g. while the /m/ duration is measured and presented, the duration of the /l/ segment is not presented). Furthermore, Williams elicited the source words from carrier sentences. Within these carrier sentences the intonation pattern may have played a role. Without knowing the nature of the carrier sentences (or if they matched), it must be pointed out that the overall intonation pattern of the original elicitation sentences may have affected the perception of the stress patterns (regardless of whether the carrier sentences were the same or not). In fact Williams refers to the issue of the source word pitch patterns remaining in her two non-monotone conditions: "the resultant F0 patterns both differed from the superimposed contour and also retained the distinction by source word" (ibid: 384). Thus, the actual alignment of pitch movements on the word (i.e. in the first or second syllable) was at best not well explained and thus the exact effect of the superimposed F0 contours could have been better investigated. There was also not a great difference between the raw numbers in the study of the F0 patterns. The monotone pitch contour resulted in 188 *ymlâdd* (final stress) judgements while the fall/step-down contour resulted in 229. The step-up and fall contour resulted in 203 *ymlâdd* (final stress) judgements. These numbers show that while the results may have come out as significant when source word was taken into account, there was only a tendency for the fall/step-down stimuli to be perceived as more like *ymlâdd* (final stress). There are a number of issues with this perception study, not least the use of the single "stress-related minimal pair" (Williams, 1985: 383). However, the pair of words *ymladd* /ˈəmlað/ "to fight" and *ymlâdd* /əˈmlaːð/ "to tire onself" are not minimal in stress alone. As can be seen from Williams' transcription, the final word with final stress has a phonologically long vowel in the final syllable while the word with penultimate stress has a phonologically short vowel in the final syllable. There is a clear criterion for the distinction of the words based on the phonological vowel length in the final syllable. Furthermore, the data collection technique was weak, each stimulus was presented only once to 10 listeners. The data could thus contain anomalous results, which could have skewed the results. Further repetitions of each of the stimuli in the perception experiment could have fixed this basic methodological flaw.

In a more recent study, Webb (2011) studied eleven female speakers: five Standard Southern British English (SSBE) monolingual undergraduates studying at university in north Wales and six female students from Welsh-speaking homes attending a Welsh-medium secondary school in Caernarfon, north Wales. Webb designed two sets of stimuli: one English (which was elicited from both the monolingual and bilingual speakers) and one Welsh (elicited from just the Welsh speaking students). The stimuli were carrier sentences containing words designed "as pairs in which the initial syllable was the same or as similar as possible in both English and Welsh, with the post-stress consonant being either /n/ or /s/" (ibid. 2107) (e.g. English *cannon* and Welsh *canol* 'centre', English *panel* and Welsh *panad* 'cup of tea or coffee'). The carrier sentences were "Say [word] again" for the English data and "Dudwch [word] eto" *Say [word] again* for the Welsh data.

Webb found that both the post-stress consonant duration and the vowel duration were significantly predicted by variety. The post-stress consonant duration (calculated as a percentage of total word duration) revealed that there was a significant difference between varieties and post hoc comparisons showed that there was a) a significant difference between the duration of the post-stress consonants of the SSBE speakers and the English of the Welsh speakers (Welsh-English consonants were longer), and b) a significant difference between the SSBE and Welsh post-stress consonants (Welsh consonants were longer). There was no significant difference in post-stress consonant length between the Welsh English and Welsh post-stress consonants. Webb also found a significant difference between languages for the length of the vowel. For this measure, differences were found between all three groups: SSBE, Welsh-English and English: the stressed vowels were *longest* in SSBE and *shortest* in the Welsh, with the Welsh-English falling between the two. This data provides support for the previous work by Williams (1989) that Welsh "stressed" vowels are shorter than the unstressed vowels, and that the post-stress consonant may well be used to indicate stress. Webb's (2010) study is well controlled and may have been better than Williams' in that the test words were always followed by another word, meaning the unstressed syllables never occurred utterance finally. However, all of the test words contained a penultimate (stressed) syllable that was compared to a word-final (unstressed) syllable. As discussed above, it has been found that even word-finally segments can be lengthened (Lehiste, 1972) and thus further investigation might do well to compare penultimate stressed syllables with antepenultimate unstressed syllables, which would not be subject to final lengthening.

Stress as separate from prominence

Perhaps the most salient feature highlighted by observational studies such as Jones (1949), Watkins (1961), Thomas (1967), Oftedal (1969) is that the pitch peak in Welsh may occur independently of the stressed syllable. Williams' (1985) data seemed to confirm this: a pitch change on the ultima of a regularly stressed Welsh word featured a pitch change greater than 10Hz. Just as previous researchers had done, Williams (1985, 1989) suggested that this was indicative that *stress* and *prominence* in Welsh occur independently from one another. The stress (indicated by the length of the post-stress consonant) occurs on the penult, while the prominence (associated with the pitch peak) occurs on the ultima in regularly stressed polysyllables.

This is one of the reasons given by Jones (1949: 63) for the phenomenon whereby the penultimate (stressed) syllable may be lost in weakly stressed words in a sentence, for example, *'ma* for *yma* 'here' and *'di* for *wedi* 'post/after'. Jones (1949: 63) attributes this phenomenon in part to the higher pitch that is found on the ultimate syllable following the penult. This is explained "historically by reference to the prehistoric shift of the British accent from the present final to the penultimate syllable. It seems that the process was not so much a 'shift' of the accent as a loss of the stress element with retention of the pitch element on the final syllable, where on the whole it has remained ever since." (ibid: 64).

Bosch (1996: 137) also discusses the "two kinds of prominence" that seem to be at work in the phonology of modern Welsh, that is "prominence of the final syllable and prominence in the penult". She also states that the prominence of the final syllable corresponds to pitch prominence while the prominence of the penultimate syllable corresponds to stress. She argues that the penultimate syllable is therefore "structurally weaker than the ultima" (p. 137) in terms of the phonological processes (such as vowel reduction and syllable deletion) that occur.

Summary

The studies presented in this section have shown that a fair amount of work has been undertaken on stress in Welsh following on from the early observations of Jones (1949), Watkins (1961), Thomas (1967) and Oftedal (1969) that the actual acoustic properties of stress in Welsh differ from the traditional acoustic properties of stress in most European languages. Instrumentally, Williams (1985) and Webb (2011) find that Welsh has a longer post-stress consonant as well as a shorter stressed vowel. However, as discussed above, there were a number of flaws with the work of Williams (1985, 1989). The results do not necessarily imply that there are different cues to stress production or perception for Welsh than in English. The differences could have been attributed to the location of the words in the utterance, the lack of repetitions in the data and these features may not have been found in all varieties of Welsh. Furthermore, it is claimed that Welsh features a pitch peak on the final syllable in the varieties of Welsh studied.

The distinction between the stress and pitch prominence in Welsh may have implications for the alignment of intonational targets in the present study. In a study of intonation it is important to consider the stress patterns of a language and how this may be separate from accentuation. If it is indeed the case that stress and prominence are independent and that this is manifested through the realisation of one on the penultimate syllable and the other on the final syllable, then this may have an effect of the location of pitch accents in the word. It could be expected that Welsh may feature a pitch accent that aligns with the final syllable in polysyllabic words if we take into account the previous work on stress and prominence in Welsh.

3.2 **Prosodic structures**

As part of a study on intonation, it is important to discuss prosodic constituency that may be present in the utterances under investigation. As discussed in Chapter 1, the autosegmental-metrical approach sees a linking between the metrical representation of the text and the pitch accents, phrase accents and boundary tones making up the tune (Pierrehumbert, 1980; Pierrehumbert and Hirschberg, 1990: 308). Pierrehumbert (1980: 10) states that the metrical representation "tells us which syllables are stressed and which are unstressed, and also describes the relationships in strength among the stressed syllables. The strongest stress in the phrase, the nuclear stress, will have a particularly important role in the description of intonation". Several studies on Welsh have discussed the division of utterances of speakers into smaller prosodic constituents, but Hannahs (2013) provides the most comprehensive overview of prosodic structures in Welsh as evidenced by the occurrence of a number of phonological processes. While this section discusses the foot and the prosodic word, further research on prosodic constituency at a higher level is required.

The foot

This section briefly discusses foot structure as proposed by Hannahs (2013). Hannahs (2013: 47) suggests that "the foot is of particular importance in the phonology of Welsh", noting that Welsh shows a preference for binary feet. Binary feet may consist of two syllables if bisyllabic (as in example k)) or two moras if monosyllabic (as in l) below). Note that monosyllabic content words are minimally bimoraic.

k)	[ˈσ σ]$_{\Sigma}$	*bisyllabic foot as in:*		
	[ˈaval]	*afal*	'apple'	
	[ˈdəsgɨ]	*dysgu*	'learn/teach'	(Hannahs, 2013: 48)

l)	[μ μ]$_{\Sigma}$	*bimoraic foot as in:*		
	[tʰɨː]	*tŷ*	*'house'*	
	[sɨːð]	*sudd*	'juice'	(Hannahs, 2013: 48)

As discussed above, regular stress in Welsh is penultimate, and thus a bisyllabic foot will be trochaic (the leftmost syllable is stressed), as can be seen in k) above. In polysyllabic words, the rightmost foot bears the main stress as in m):

m) [σ σ]$_{\Sigma}$ [ˈσ σ]$_{\Sigma}$ or [μ μ]$_{\Sigma}$ [ˈσ σ]$_{\Sigma}$ *as in polysyllabic words:*
[ˌɬəia]$_{\Sigma}$ [ˈvrivɔɨð]$_{\Sigma}$ [ɬəi]$_{\Sigma}$ [ˈavriv]$_{\Sigma}$
minorities *minority* (Adapted from Hannahs, 2013: 48)

As this thesis considers the suprasegmental structure of Welsh with regards to intonation, the reader is referred to Hannahs (2013, Chapter 3) for a further discussion of word minimality and the treatment of polysyllabic words in Welsh.

The prosodic word

Bosch (1996: 149) suggests, "the smallest phonological domain in Welsh relevant to the assignment of metrical structure is that of the phonological word – there appears to be no evidence for referring to a smaller domain, such as the stem for the purposes of syllabification or metrification". Hannahs (2013) also discusses the phonological word as a constituent in the prosodic structure of Welsh. The prosodic or phonological word is said to play "an important role as the domain of various phonological processes in the language" (ibid. 49). Stress, for example, is applied to a prosodic word, with each prosodic word bearing one main stress.

In the consideration of strict and loose compounds, a strict compound features single stress on the penult while loose compounds feature stress on both parts of the compound.

n) fferm + tŷ → *ffermdy* [ˈfɛrmdɨ]
farm + house → farmhouse

o) *ôl + ysgrif* → *ol-ysgrif* [ˈoːl ˈəsgriv]
post + script → postscript (Adapted from Hannahs, 2013: 48)

Hannahs suggests that example n) *ffermdy* thus consists of one prosodic word while the compound in o) *ol-ysgrif* contains two prosodic words. Previous researchers such as Morris-Jones (1913) and Watkins (1961) have also provided such pairs where strict compounds feature a single primary stress and loose compounds feature two stresses. Bosch (1996) also discusses these compound formations as evidence for the prosodic word, citing Morris-Jones' (1913) strict compounds with single stress on the penult (e.g. *gwin* + *llan* → *gwinllan* [ˈgwɪnɬan] "wine + gleve → vineyard") and loose compounds which remain as "two distinct phonological words, and two separate stress domains" (Bosch, 1996: 151) (e.g. *prif* + *dinas* → *prifddinas* [ˈpriv ˈðɪnas] 'chief/main + city → capital city'). Thus "a strict compound is equivalent to a single stress domain, while a loose compound represents two distinct stress domains. A stress domain is coextensive with a single phonological word" (ibid.: 153).

While this thesis does not investigate the realisation of strict and loose compounds in Welsh, it is important for the assignment of metrical structure to cite works that discuss the phonological structures within Welsh.

Prosodic structures above the phonological word have not been explicitly discussed as far as is known (Hannahs, 2013). Bosch (1996: 139) notes "clearly, further research is needed on this topic, specifically to address sentence-level as well as word-level stress, pitch, and feature changes". Work on sentence level stress in Welsh is lacking, with discussions in Morris-Jones (1913), Jones (1949) and Watkins (1961) focussing on the phonological processes of connected speech (loss of the penult, vowel reduction, compounding), rather than discussing the accentability of lexical items in connected speech. In Chapter 3, Section 3, this question is addressed using the data set collected for this thesis.

3.3 Intonation

Research on the intonation of Welsh has been neglected greatly, with Ball and Williams (2001: 164) noting, "little instrumental work on pitch movements in Welsh exists". Nevertheless, there are a number of studies, which, although problematic in some respects, highlight interesting points for consideration for the present thesis.

As Ball (1989: 91) points out, previous research has focused on two approaches to transcribing intonation, one using diacritics (e.g. [^] for a rise-fall) following the standard of O'Connor and Arnold (1973) for English, and the other using a numerical system to show rises and falls in pitch level (e.g. [^{32}] for a rise). A further discussion in this section will describe the ToBI style analysis applied to the Welsh language by Evans (1997). The different researchers working on Welsh intonation have used different ways of *grouping* the words over which intonation operates (the word group, sense group, tone group) (Ball, 1989: 92). Thus, with each new piece of research discussed in this section, the method and unit of grouping or phrasing for intonation will be outlined. Given these different approaches to the description and analysis of Welsh intonation, work by individual researchers is presented separately. A synthesis of the differences and similarities of findings will then be presented at the end of this section.

Watkins (1961)

Watkins (1961) uses the numerical transcription method (1 referring to high pitch, 2 middle, 3 low) with standard orthography to show intonational patterns of different types of sentences. His work is based on the Cwmtawe dialect that is spoken just north of Swansea, South Wales. Watkins (1961: 29) distinguishes four types of intonational patterns in this variety of Welsh. The first type is found in statements and commands, consisting of a falling pitch pattern from 1-2-3:

p) ^{1}Torrodd ^{2}John ^{3}y ffenestr
break.3S.PAST John the window.
'John broke the window.'

The next relevant intonation contour that Watkins (1961: 30) distinguishes is the 'elevated accent' found in questions marked by question particles (from 3-2-1):

q) ^{3}Ai ti ^{2}a torrodd ^{1}y ffenestr?
PRT you break.3S.PAST the window
Was it you who broke the window? ~ Did you break the window?

However, in spontaneous speech (as discussed in Section 2 of this chapter), the question particle has now disappeared and the tone is the only distinguishing element between the statement and the question. The two examples below show that Watkins identifies them as syntactically identical, with the question featuring a rising pitch movement (3-2-1) and the statement featuring a falling pitch movements (1-2-3)*:*

r) ^{3}Welodd ^{2}John ^{1}y bachgen?
see.3S.PAST John the boy
'Did John see the boy?'

s) ^{1}Welodd ^{2}John ^{3}y bachgen.
see.3S.PAST John the boy
'John saw the boy.'

The final type of question is the pronominal or wh-question, which ends with a low tone and thus differs from the intonation pattern observed in yes-no polar questions (as exemplified in examples q) and r) above). Watkins shows that this falling pitch is similar to that of the statement, with a declining pitch from 1-2-3.

t) ^{1}Pwy ^{2}torrodd ^{3}y ffenestr.
Who break.3S.PAST the window
'Who broke the window?'

One of the main issues that Watkins (1961) does not address explicitly is the shape of the intonation contours he describes. He presents the overall upward or downward trend of each question type (falling for statements and wh-questions, rising for yes-no questions), and simply notes that within the sentence pattern, the word pattern can be found: "tu mewn i'r brif dôn yn y frawddeg… mae is-dôn eiriol: ^{2}to^{1}rrodd" *Within the main tune of the sentence… is the lower word tune: ^{2}to^{1}rrodd*. This could be taken to be indicative of the rising pitch from penultimate to ultimate syllable in regularly stressed words (see Section 3.1 above), or simply indicative of a rising pitch movement found on each lexical item in the utterance. However, his observations as to the direction of the pitch contours provide a good starting point for other researchers, as described below.

Thomas (1967)

Thomas' (1967) more in-depth study on Welsh intonation provides a description of the intonation patterns of Welsh speakers from the Nantgarw district in the Taff Valley, seven miles north of Cardiff. Thomas uses the diacritic method to transcribe the intonation of Welsh. She uses the "sense group" as the unit of description: a closely knit group of words, usually separated by pauses over which an intonational tune extends (cf. similar to what is nowadays most commonly referred to as an intonational phrase). Words may be stressed within the sense group but they may not necessarily be prominent: "important words in a sense group, will be stressed and there will be a pitch contrast between them and unimportant words surrounding them, whose stressed syllables are pronounced with lessened intensity" (Thomas, 1967: 8). The structure of the sense group consists of a compulsory nuclear tone followed by an optional tail and preceded by an optional prehead and head:

(prehead) (head) nucleus (tail)

In her discussion of tones found on the nucleus (the last prominent word in the sense group), Thomas recognises eight nuclear tones: two falling glides, three rising glides, one compound glide and less common level tones:

- Low Fall: "begins at or below the middle of the normal voice range and drops to the bottom"
- High Fall: "begins near the top of the normal voice range and drops to the bottom"
- Low Rise: "starts near the bottom of the normal voice range and rises to the middle or below the middle of the voice range"
- High Rise: "begins near the middle of the normal voice range and rise almost to the top"
- Full Rise: "begins at the bottom of the normal voice range and rises to the top"
- Rise Fall: "begins at the bottom of the normal voice range and rises to near the middle and falls back again"
- High level: "above the middle of the voice range"
- Low level: "near the bottom of the normal voice range"

(Thomas, 1967: 9-10)

Thomas distinguishes a great deal of patterns available for the primary nuclear tone. Thomas also identifies four pre-heads: Normal pre-head (mid-level), High Rising pre-head (occurring only with Low-Fall or Rise-Fall nuclear tones), High Level pre-head (occurring only with full-rise and low-level nuclear tones) and the Low-Level prehead (occurring with High-Fall and High Level).

Ball (1989: 92) suggests that Thomas' analysis of the head unit is "somewhat more tentative, with three types identified but mixtures of these types are also thought to be found". The three types of head found were a Saw-toothed head, a Rising head and a Level head. Within the Saw-toothed head, if more than one prominent syllable occurs before the nuclear tone, a rising contour is added prior to the already rising prominent syllable. This results in all prominent syllables occurring on a declining plane but with the intermittent non-prominent syllables rising (perhaps an effect of the higher pitched ultima) (Thomas, 1967: 14-16). Within the Rising head, rising contours are present but they rise one above the other from a low level (and this is usually accompanied by a high prehead) and each additional syllable begins at a higher pitch than that of the last syllable of the preceding contour: the voice can rise steadily throughout this part of the tone (Thomas, 1967: 16-18. The Level head occurs where the prominent and non-prominent syllables are realised as level: no rising or falling between them. These three heads are said to be added to nuclear tunes to produce a number of combinations and there appears to be no restrictions as discussed with the prehead. Furthermore, within the tail (any post nuclear syllables), the direction of the glide begun on the nuclear syllable is continued through these syllables either at the same level or in the same direction (Thomas, 1967: 19).

Thomas' analysis distinguishes a great number of elements that can combine to form simple tunes (consisting of the compulsory nuclear tone and an optional tail), or complex tunes (with other features occurring on the head and prehead), and possibly further nuclear pitch movements. While Thomas notes that "emphatic sentences" may be constructed from combinations of the elements described above, the reader is left with very little information about the functional uses of the tune types. Thomas' study provides an inventory of tones that were found without explicit reference to grammatical or emotional function. While the auditory analysis provides a good idea of the types of patterns perceived in Natgarw Welsh, without explanation of the materials used or further instrumental analysis, the reader is left to speculate about the types of contours found for different grammatical patterns in the dialect.

Pilch (1975)

Pilch's (1975) study of Welsh phonemics contains a section on intonation, or in his terminology, 'the contour'. Pilch's study is based on the speech of a Welsh-speaking informant from Aberystwyth. He uses a numerical method to transcribe the three different pitch levels of Welsh: "*high* /1/, *mid* /2/ and *low* /3/" (ibid.: 72). The description of contours operates over major stress groups or "phonological words". Pilch identifies four types of contour, and they appear over "one or several successive phonological words" (ibid. 80). The first pitch pattern is *The High-low Pattern* (/1 2/) which features an abrupt pitch-drop at the beginning of the last major stress group. The first stress group is on a higher pitch-level than the second. This pattern indicates a declining pitch pattern over the utterance, as we found in Watkins (1961) (see page 59 of this chapter). This is found with statements and wh-questions:

u) ^{1}‘beth ^{1}ych chi neud ^{2b}bore ma?
what be.2S.PRES you do.nonfin morning this
‘What are you doing this morning?’

The Low-High (/2 1/) pattern is also described, which features an abrupt pitch rise, which Pilch (1975: 82) describes as giving “emphasis to the last major stressgroup”. This is also followed by a fall on the coda (tail) represented by the superscript 3.

v) ^{2}‘bore ^{1}da ^{3}i chi
morning good to you
‘Good morning to you?’

A *High Pattern* is also described by Pilch. This involves a high pitch throughout from the beginning or the middle of the first to the end of the second major stress group:

w) ^{3}a ^{1}’oes da ti ^{1}’lythyr, ^{1}i fi?
PRT be.3S.PRES with you letter for me
‘have you got a letter for me?’

This pattern is different to Watkins’ rising pattern found in yes-no questions (see page 59 of this chapter). Pilch represents this yes-no question with continuous high pitch over the utterance, which appears to indicate a high-level pitch manifestation.

The final pitch pattern highlighted by Pilch for Welsh is the citation pattern: concave-rising (rise fall) followed by a concave falling (level) over two major stress groups as in the idiom below (note superscript 2a refers to the rise fall and 2b refers to the level):

x) ^{3}i chi’n rhoi ^{2a}’pen ^{3}ar y ^{2b}mwdwl
you PRT put.NONFIN on the haycock
‘you are putting the finishing touches to your work’

Pilch’s work is, like Watkins and Thomas based on observational data and his paper on *phonemics* simply provides examples of the pitch contour without a great deal of explanation as to the function. Nonetheless, we are given an account of the direction of pitch patterns in the Aberystwyth Welsh he describes.

Rees (1977) and Rhys (1984)

Rees' (1977) thesis on aspects of Welsh intonation precedes his Rhys (1984) paper on Welsh intonation in the discourse. In both papers, he provides an auditory analysis of spontaneous speech in Welsh from southeast Dyfed aiming to relate "the structure of intonation to its function in discourse" (Ball, 1989: 93).

In both Rees (1977) and Rhys (1984), the author approaches the transcription of the intonation patterns using pictorial representations of the pitch movements (following Halliday, 1970). The basic intonational unit is the tone group, consisting of the compulsory tonic syllable (holding the main phonological prominence in the tone group). This tonic syllable is optionally preceded by a pretonic (the element from the first salient syllable up to the tonic) and the proclitic (consisting of any non-salient syllables preceding the pretonic). The tonic syllable is also optionally followed by the post-tonic (consisting of any further syllables in the tone group):

(proclitic) (pretonic) tonic syllable (post-tonic)

The proclitic features little variation in pitch: the syllables being more or less on the same pitch level (Rees, 1977: 29), unless being used to mark a) emotional speech or b) assimilation with the preceding utterance. Three patterns are posited for the pretonic (head): stepping, level and rising. The stepping pretonic occurs when each salient syllable in the pretonic comes at a lower pitch than the preceding salient syllable. This is equivalent to Thomas' (1967) saw-toothed head. The level pretonic sees the salient syllables at a level pitch and the rising pretonic sees each syllable on a pitch level higher than the preceding one (Rees, 1977: 35). Much of the discussion of the post-tonic syllables (the tail in Thomas, 1967) is undertaken in the discussion of the tonic syllable. Rees/Rhys aims to discuss the function of intonation and does not give a great deal of attention to these non-obligatory constituents in the tone group.

However, in his discussions of the tonic syllable, much more information with regard to discoursal function is provided. Four main categories of intonation are described for the tonic syllable: the fall, the rise, the rise-fall and the level. The fall, when no post-tonic syllables occur will take place "entirely on the tonic syllable' but "a good deal of the downward pitch movement may take place" on the post-tonic syllables if they are present (ibid. 316). The rise "mirrors the falling tone" (ibid. 318) in that the fall will occur on the tonic syllable but may spread if post-tonic syllable are present. Remaining post-tonic syllables will occur on a level pitch following both the rise and the fall. The rise-fall will also take place entirely on the tonic syllable if no post-tonic syllables are present, but if the tonic vowel is long and post-tonic syllables are available, “then the tonic syllable may carry the rising component of the tone only” (ibid.: 320). The level tone is not given a great deal of consideration; it is maintenance of a level pitch from the tonic syllable to the end of the tone group.

Importantly Rees/Rhys gives discoursal function to these patterns found on the tonic syllable: Tone 1 (the rise-fall and fall) representing ‘resolving’ function in discourse while Tone 2 (level and rising tones) represents a non-resolving function. Rees/Rhys also discusses “tonicity” (the selection of the tonic syllable) for the Tone 1 examples. Unmarked tonicity occurs when the tonic syllable is the lexically stressed syllable of the last lexical item in the tone-group (broad focus), while marked tonicity occurs when the tonic syllable is on a non-final lexical item, is the lexically stressed syllable of a non-lexical item or where the tonic syllable is a syllable which is not lexically stressed (narrow focus). The marked tone is realised when the onset of a falling tone is at a pitch level above that of the final syllable in the pretonic, or where the movement is a rise fall (as represented in Figure 2 below). The unmarked tone occurs when the nuclear tone follows at a pitch lower than the final syllable in the preceding pretonic.

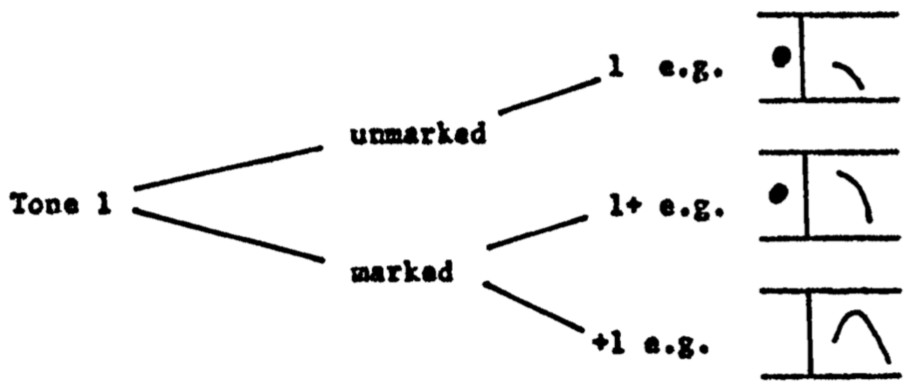


Figure 2: Marked and unmarked tones in tone 1, from Rees (1977: 329)

Instances of marked tone 1 (narrow focus) are used when contrastive presupposition is present. The marked tone shows that the narrowly focused item contrasts with something previously mentioned in the discourse. For further discussion of the marked and unmarked tone, the reader is referred to Rees (1977: 329-335). Very little further explanation of the actual tune types is found in either Rees (1977) or Rhys (1984). Ball and Williams (2001: 209) write that Rhys' "analysis of structure is therefore less full than" the other studies of intonation such as Watkins, Thomas and Pilch.

Evans (1997)

A small ToBI style analysis of Welsh was conducted by Evans (1997). She attempted a basic autosegmental-metrical analysis of a South Wales (Cardiff) dialect following the ToBI transcription method (see Chapter 1). Evans found five types of nuclear pitch accent:

- H* (pitch peak on the accented syllable)
- L* (L target on the accented syllable)
- L*+H (Low valley on the accented syllable followed by a rise)
- L+H* (high peak on the accented syllable which is preceded by a rise from a valley)
- H+L* (low peak on the accented syllable preceded by a fall from a peak)

Evans' study does not provide any specific information as to the alignment of the tonal targets (H*, L*) in the data, other than what can be interpreted from the use of the ToBI labels, for example the H* features a pitch peak aligned to the accented syllable, and in L* the L target is aligned to the accented syllable. A difference in the alignment of the rises outlined by L+H* and L*+H can also be deduced. In L+H* the rise begins before the accented syllable while in L*+H the rise begins on the accented syllable.

Evans also finds two phrase accents and two boundary tones L-, H-, L% and H%. These may be combined into a number of contour shapes. Evans' study is basic in that it merely describes some occurrences of the pitch accents in her inventory but gives no general patterns related to function apart from stating that the main nuclear declarative pattern is a rise-fall of L* H-L% (Low, high, low). The lack of specific phonetic data is also problematic as it provides us with no basis for comparison with other varieties of Welsh (this is a general issue with ToBI transcription methods which is discussed in depth in Chapter 5).

Synthesis

This section presenting the previous research on Welsh intonation has shown that the research methods used vary from study to study. This makes finding similarities between these studies difficult. The studies cover different transcription methods: numerical (as in Pilch), diacritic (as in Thomas), pictorial (as in Rhys) and an autosegmental-metrical transcription (Evans). However, Ball (1989) provides an attempt at synthesising the findings from the above-described studies. This is shown in Table 2 below, which has been adapted from Ball (1989) to include the findings of Evans (1997).

Table 2 Classification of nuclear tones in four studies of Welsh intonation

Thomas (1967) Nantgarw	**Pilch (1975)** Aberystwyth	**Rees (1977) and Rhys (1984)** South-East Dyfed	**Evans (1997)** South Wales ~ Cardiff
Low Fall High Fall	Convex-falling Convex-falling (high)	Fall	H+L*
Low Rise High Rise	Convex-rising (low) Convex-rising	Rise	L+H*, L*+H,
Full Rise Rise Fall	Concave-rising (high)? Concave-rising	Rise-fall	L* H- L%
High level Low level	Concave-falling Concave-falling (low)	Level	L* L- L%

Adapted from Ball (1989: 93) and Evans (1997)

As can be seen from the table, all four researchers found similar patterns using various methods. However, there are some differences in detail between the studies, with Rhys proving general labels for his categories and Thomas and Pilch providing greater detail with regards to realisation within each category. However, without specific detail as to the phonetic realisation of the intonation patterns in the varieties, it is very difficult to find commonalities between the studies. Ball and Williams, (2001: 197) when discussing Evans (1997) write that "it is hoped that in the near future it will be possible to annotate more Welsh speech … in order to derive accurate quantitative data on the acoustic characteristics of intonation in Welsh". This highlights the fact that the observational studies of intonation outlined above are lacking in that they are based on auditory perception. This is not to say that auditory analysis is not an important method in the study of intonation, but the observations need to be supported with instrumental and experimental evidence to confirm these observations on a larger scale.

4 Summary and thesis outline

This thesis is intended to contribute to our understanding of the intonation system of a northern Welsh variety following the AM approach to intonational analysis. This chapter has focussed on outlining some of the previous research on stress and intonation in Welsh. Firstly, this chapter has highlighted that previous research on Welsh suggests that there may be dissociation between stress and accent. While rhythmic stress in polysyllabic words is said to fall regularly on the penultimate syllable, accent (indicated by increased pitch) is said to occur on the final syllable. This may have important implications for the realisation of intonational pitch accents in Anglesey Welsh. As previously mentioned, pitch accents may align with the final syllable in polysyllabic words. Furthermore, this chapter has summarised some of the previous research on Welsh intonation, highlighting that there is a lack of in-depth instrumental research in general. As a result, the main aim of this thesis is to provide a fine-grained intonational analysis of a northern Welsh variety by investigating empirically its phonetic realisation and phonological structure.

Chapters 3 and 4 will be concerned with aspects of the phonetic realisation of tonal targets in Anglesey Welsh intonation, concentrating on the intonational encoding of interrogativity. Chapter 3 is concerned with the scaling of the tonal targets while Chapter 4 investigates the alignment of the targets in relation to the segmental string. Together, these chapters will not only explore how grammatical function can affect the phonetic realisation of intonation, but will also investigate how temporal constraints can influence the realisation of tonal targets. Chapter 5 uses the data found in Chapters 3 and 4 to provide a critique of present autosegmental-metrical transcription systems and proposes a tentative description for Welsh. Chapter 6 features a summary of the major findings and concludes the thesis.

Chapter Three

Scaling of tonal targets

The autosegmental-metrical (AM) approach adopted for this thesis is based around abstract phonological levels or *tones*. These abstract tones (H and L) are accompanied by a set of phonetic implementation rules, which control the phonetic implementation of this phonological representation. The result is phonetic *tonal targets* (for example, the F0 maxima or minima). The phonetic implementation rules denote the vertical height of these tonal targets within a speaker's pitch range and their temporal alignment to the segmental string. This chapter concerns itself with the vertical height or "scaling" of the intonational targets in the contour while Chapter 4 considers their temporal alignment. Ladd (2008a: 199) states that in several European languages "the scaling of pitch targets is highly systematic". Nevertheless, the scaling of tonal targets has been shown to vary as a result of a number of factors including a) grammatical function (e.g. encoding interrogativity) (Haan, 2002; Grabe, 2004, Makarova, 2007) and b) temporal constraints (proximity of tonal events such as upcoming pitch accents and boundary tones) (Arvaniti and Ladd, 1995; Arvaniti, 2003; Prieto, 2005, Arvaniti, Ladd and Mennen, 2006). This chapter thus investigates the way in which these two factors affect the scaling of tonal targets in Welsh data.

The first part of this chapter discusses the two features (grammatical function and temporal constraints) under investigation. Research questions arising from these considerations are considered in Section 2. The method of data collection and analysis is outlined in Section 3 followed by the results in Section 4. A discussion concludes this chapter in Section 5.

1 Factors affecting the scaling of tonal targets

1.1 Sentence type

As discussed in Chapter 1, questions are usually – although not necessarily – distinguished in some way from their statement counterparts in order to achieve the communicative function of interrogativity. The distinction can be lexico-syntactic with the use of question words or inversion, or it can be encoded by means of intonation, usually involving some sort of high pitch. Languages differ in how the communicative function of interrogativity is expressed lexico-syntactically. We saw in Chapter 1 that languages such as Dutch and English have subject-verb inversion as well as wh- question words whilst other languages such as Greek, Russian and Italian feature no subject-verb inversion for the marking of wh or yes-no questions. Hirst and Di Cristo (1998: 19) state that "practically all the languages" in their survey of the intonation systems of twenty languages feature a rising-falling pitch movement over the utterance finishing on an extreme low pitch in declarative utterances. Whilst other features are common of declaratives in a number of varieties (such as rising final pitch in northern British English, Extremadura Spanish and Corfu Greek), a generally falling pitch at the utterance end is the most common in the languages surveyed (ibid. 19).

In contrast, one of the most frequent characteristics found in yes-no questions is the raising of the pitch in all or part of the utterance ("whether or not the utterance finishes with a final rise") (Hirst and Di Cristo, 1996: 19). This raising of pitch is common in many languages and it is found that yes-no questions often have a *raised nuclear accent peak* (Haan, 2002). In a study by Makarova (2007), it was found that Russian interrogatives were scaled significantly higher than declarative counterparts (she also found an effect of sentence type on the alignment of these peaks: interrogative peaks were not only higher, but they were also later- see Chapter 4). Furthermore, yes-no questions often feature a *high final pitch* (as found in a 13 of the 20 languages in Hirst and Di Cristo's (1996) survey). However, this feature is not seen in all languages for interrogative utterances. For example, Geluykens (1988) in his study of 200 questions found that British-English yes-no questions did not always feature rising intonation and suggested that this issue is far from conclusive.

Wh-questions, on the other hand are often distinguished by a wh-word that occurs utterance initially, and thus they are marked explicitly for interrogativity with this lexical marker. A high accent is usually found on the wh-word (Haan, 2002). Many languages (English, Spanish, Romanian, Russian, Greek) are described as having wh-question intonation that is similar to statements rather than yes-no questions (Hirst and Di Cristo, 1996: 26), with the pitch falling over the duration of the utterance.

As discussed in Chapter 1, Haan (2002) proposed a Functional Hypothesis for her study of Dutch intonation. She proposed that there might be a trade-off between the intonational features described above to mark interrogativity (i.e. final rising pitch, raised nuclear accent peaks, raised register level and suspension of downtrends) and the amount of lexico-syntactic marking for interrogativity in an utterance. She tested this functional hypothesis by looking at four sentence types that varied in their lexico-syntactic marking. She confirmed that the most intonationally marked questions were declarative questions (DQ), which were not otherwise marked for interrogativity. In yes-no questions (YQ) which in Dutch feature subject-verb inversion, the final rise and raised nuclear accent peaks were less common, and these features were least common in the wh-questions (WQ) which had both a question word and subject-verb inversion.

This 'trade-off' between lexico-syntactic marking and intonational marking has also been found for English (Grabe, 2004). Grabe found nine dialects in which questions (declarative questions), which were not lexico-syntactically marked for interrogativity, were found to contain the maximal intonational marking. Grabe expanded Haan's approach by making phonological transcriptions of the nine dialects and categorised the nuclear pitch accents into "rising" and "not rising". She found that the incidence of final rising patterns was greater in questions than in statements for all nine varieties. She also found for most of the varieties that the incidence of final rising nuclear accent was variable as a function of lexico-syntactic marking. That is, the most lexico-syntactically marked questions that featured a question word and inversion (wh-questions) featured the fewest nuclear rising pitch accents (only statements featured fewer). A nuclear rising pitch accent was present most often in the declarative questions (which are lexico-syntactically identical to the statement counterparts) and yes-no questions (which featured only inversion).

As described in Chapter 1, Welsh is an interesting language (as compared with English or Dutch) when it comes to interrogativity because there is no subject-verb inversion present in questions as compared with statements. The table below illustrates the lexico-syntactic marking of the statement (ST) and question types in Welsh. As can be seen from Table 3 below, wh-questions (WQ) are an example of the *most* lexico-syntactic marking in Welsh: an *additional* question word is present to mark the wh-question as such. The difference between a statement and a yes-no question (YQ) in Welsh is minimal: if the periphrastic construction is used (see Chapter 2), a *different* form of the verb *to be* may be used. This form of the verb *to be* is the only lexical indicator of interrogativity and does not occur in every yes-no question. The minimal lexico-syntactic marking in Welsh is seen in the declarative questions (DQ), as in English and Dutch, they are lexico-syntactically identical to their statement counterparts.

Table 3 Lexico-Syntactic marking of the statement (ST) and three question types: wh-question (WQ), yes-no question (YQ) and declarative question (DQ)) in Welsh. The question word is in bold.

Statement (ST)	Mae Manon yn flin. be.3S.PRES Manon PRT angry	"Manon is angry"
Wh-Question (WQ)	**Pam** mae Manon yn flin? why be.3S.PRES Manon PRT angry	"Why is Manon angry?
Yes-no question (YQ)	**Ydy** Manon yn flin? be.3S.PRES Manon PRT angry	"Is Manon angry?
Declarative Question (DQ)	Mae Manon yn flin? be.3S.PRES Manon PRT angry	"Manon is angry?"

A secondary aim of this thesis is to investigate the Functional Hypothesis for Welsh, by investigating whether questions have higher (or later) accent peaks as compared with statements. The hypotheses arising from the case of Welsh are presented in Section 2 below, and research questions pertaining to the effect of sentence type on the scaling of the tonal targets will be outlined. However, Section 1.2 below will discuss the effects of phonetic pressure on the realisation of tonal targets, presenting previous research that shows that there may be variation in the scaling of tonal targets due to reduced space available in which to realise an intonation contour.

1.2 Temporal constraints

As was briefly introduced in Chapter 1, previous studies have found that some tonal targets may be "undershot" due to the variable spacing of tones (high targets are less high and low targets are less low). The AM assumption postulates that the tonal specification is independent of the segmental material and thus tones associate with the metrically accented syllable in an utterance. These tones can be spaced variably as a result of manipulation of the number of syllables in an utterance, due to the fact that they associate with the accented syllables. If the accented syllables are spaced close together, the tones will occur in close proximity. If the accented syllables are spaced further apart, the tones will occur further apart.

One effect of tonal crowding is tonal undershoot, where two tonal “gestures” are overlapping. For example if two rise-fall L H L movements occur close together (in conditions of tonal crowding), we might expect that the H target of the rise will be lower than in conditions without tonal crowding (D’Imperio, 2001). This is represented graphically in Figure 3 below. The top contour in the figure shows the full realisation where there is no tonal crowding, while the bottom contours show the options for tonal undershoot in conditions of tonal crowding. The bottom left contour shows that with reduced ‘space’ the H targets may be less high, while the bottom right contour shows that the L targets may be less low.

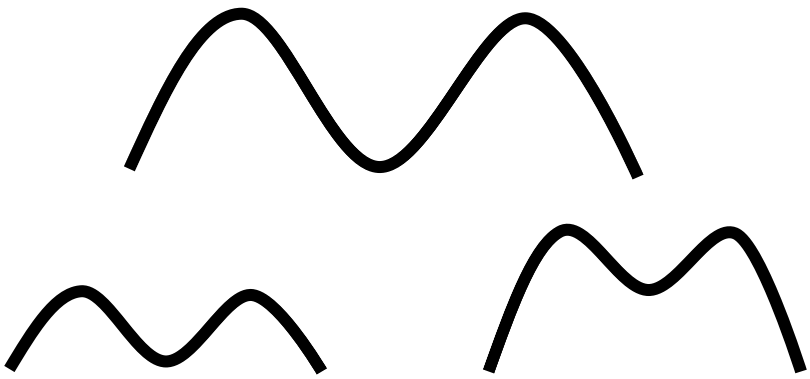


Figure 3: Schematic representation of tonal undershoot. Top: full realisation in conditions without tonal crowding, bottom left: H undershoot in conditions of tonal crowding, bottom right: L undershoot in conditions of tonal crowding

This effect of undershoot has been found for a number of languages. Arvaniti and Ladd (1995) in their study of Greek prenuclear accents found effects that the scaling of the L target between two accent peaks was affected by tonal clash. They manipulated stimuli in which two accents (A1 and A2) within the same intonational phrase were separated by progressively more unaccented syllables. In their study of three speakers of standard Greek, they found that for one speaker, in conditions where there was one unaccented syllable between A1 and A2, the low target between A1 and A2 was higher than for conditions with four unaccented syllables between A1 and A2. That is, the low was realised less low when there were fewer syllables available in which to realise the target. That is, the one intervening syllable was not sufficient to alleviate the pressure caused by the tonal crowding. However, this was not the case for all three speakers. In a further study, Arvaniti, Ladd and Mennen (1998) investigated further whether speakers of Greek would attempt to cope with the pressure caused by tonal clash using strategies such as undershooting based on the evidence from Arvaniti and Ladd (1995). While they found that the H was stable for two speakers, for one the H was found to re-align (the H was aligned earlier when there was one unaccented syllable between the accent than when there were two), but not undershoot. Furthermore, in the speaker who re-aligned the H, there was also a significantly smaller F0 difference between the L and H “providing further evidence that for this speaker one unaccented syllable between accents constitutes tonal crowding” (ibid.: 22). Arvaniti et al. (1998: 21) suggest that evidence from re-scaling and re-alignment suggests “that for some speakers having only one syllable intervening between accents constitutes tonal crowding which they try to alleviate using various strategies”. However, the re-scaling was only found to occur with the L between the two accent peaks, which was clearly higher in conditions of tonal clash.

This effect of tonal undershooting has also been found by Prieto (2005) for Spanish. It was found that the low between a prenuclear and nuclear accent peak was consistently and significantly higher when there were no intervening syllables in between the accents for all 4 speakers in the study. As Arvaniti et al. (1995; 1998) had found for Greek, the scaling of H was fairly constant across clash/no clash conditions. Prieto (2005) suggests that the fact that H has strong stability in her study of Spanish and in previous work on Greek (Arvaniti et al., 1995; 1998) while the L may be undershot in clash environments indicates “that H values as tonal targets take precedence over L” (Prieto, 2005: 216).

These findings for Spanish and Greek suggest that tonal clash and the number of syllables following the nuclear pitch accent may affect the scaling of low tonal targets. However, findings by Prieto (2005), Arvaniti et al (2006) also suggest that there may be significant adjustments to tonal *alignment* in conditions of tonal crowding. This effect will be discussed in more depth in Chapter 4.

2 Hypotheses and Research Questions

It is hypothesised that the scaling of nuclear accent peaks will be higher in questions than in statements. Specifically, the nuclear tonal targets (L and H) of questions will be scaled higher than statements. It is also expected that a high final utterance offset may be present in questions but not in statements. The scaling of the nuclear tonal targets is predicted to follow the order WQ<YQ<DQ. That is, the scaling of the tonal targets will be maximally high in the question type which is least marked for interrogativity using lexico-syntactic means (DQ) (after Haan, 2002). Questions with the most amount of lexico-syntactic marking will be scaled lowest (WQ) and the lowest scaling overall will be found in the statements (ST).

Another factor that could affect the scaling of H and L tones in both nuclear and prenuclear position is the variation in the amount of space provided for pitch movements to occur. It is expected that where there is less space for a movement to occur by reducing a) the number of syllables preceding the prenuclear accented syllable (variable name: PRECEDING) b) the number of syllables between the prenuclear and nuclear accented syllables (variable name: BETWEEN) and c) the amount of space at the end of an utterance (variable name: TAIL), that the L and H targets may be realised less peripherally; that is, lows will be higher and highs may be lower.

The following research questions have arisen from the consideration of the above information.

- Do the four sentence types (statement, yes-no question, wh-question, declarative question) differ in the height of valleys and peaks?
    - Are these points scaled higher in questions than in statements, and is this scaling gradable as a function of lexico-syntactic marking?
- Does decreased "space" affect the height of highs and lows (by reducing a) the number of syllables PRECEDING the prenuclear accented syllable, b) the space BETWEEN prenuclear and nuclear accented syllables and c) the number of post-nuclear syllables (TAIL)?

3 Method

This section outlines the method used for collecting and investigating the aims of the thesis. Read and semi-spontaneous spoken materials were designed to allow the investigation of scaling (and alignment) of tonal targets in order to answer the two research questions outlined in the previous section. The investigation of the possible grammatical function of intonation is investigated by manipulating sentence type. Four sentence types from Welsh with differing degrees of lexico-syntactic marking were chosen. Furthermore, precise variation in the phonetic realisation of tonal targets due to temporal constraints (space preceding, between and following the prenuclear and nuclear accented syllables) is investigated by manipulating the amount of material available in which to realise the intonation contour, as described below.

3.1 Materials

There were two methods of data elicitation. One involved read speech being elicited using materials that were highly controlled, and the other was a Map Task (Anderson et al., 1991). These two methods of data elicitation were chosen in order to construct a corpus that consisted of a combination of read speech and semi-spontaneous speech. The read speech is useful in studies of intonation because the "experimental control allows us to make observations by manipulating the factors under investigation while keeping other factors constant" (Xu, 2010; 334). Furthermore, it allows for the averaging of a large number of typical intonation contours for each sentence type.

It is often argued that lab speech is inadequate for studying natural speech. However as Xu (2010; 334) points out, "spontaneous speech can rarely allow us to fully control the factors that contribute to the phenomena we are interested in, which makes rigorous hypothesis testing difficult". Lickley, Schepman and Ladd (2005) defend the use of lab speech by showing that data collected from a read speech experiment could be generalised to speech produced spontaneously. Nevertheless, in order to address concerns about the representativeness of lab-speech, the map task was employed to check the robustness of the findings from the read speech data.

Pilot

A small exploratory pilot study was undertaken in order to investigate some basic features of Anglesey Welsh intonation and to test that the instructions and reading materials for the main task. One male 25-year old speaker from Menai Bridge took part in the short reading task. The task was designed to contain statements, yes-no questions and wh-questions that varied in structure (in terms of their word order) and in terms of their length. The sentences contained examples of the periphrastic (auxiliary, subject, verb, object) construction (as shown in example y) below) as well as the VSO construction as shown in example z)). The speaker read the randomised list of 52 sentences twice (full details of which can be found in Appendix A).

A number of important findings were highlighted by the pilot experiment. Firstly, the results suggested that stress and accent co-occur for this speaker of Anglesey Welsh. In Chapter 1 it was stated that one of the main characteristics of the AM approach states that pitch accents are intonational features that are associated with accented syllables. Given the literature presented in Chapter 2 regarding the apparent independence of stress and accent in Welsh (Jones, 1949; Watkins, 1961; Bosch, 1996; Williams 1985, 1989), it could have been predicted that the pitch accents may have associated with the final accented syllable rather than the rhythmically stressed penultimate syllable. However, the pilot study illustrated that accent and stress in Anglesey Welsh appear to coincide with a pitch peak associating with the penultimate syllable in polysyllabic words. As can be seen in Figure 4 below, there is a pitch movement associated with the first syllable in the two words ‘Manon’ and ‘Almaen’.

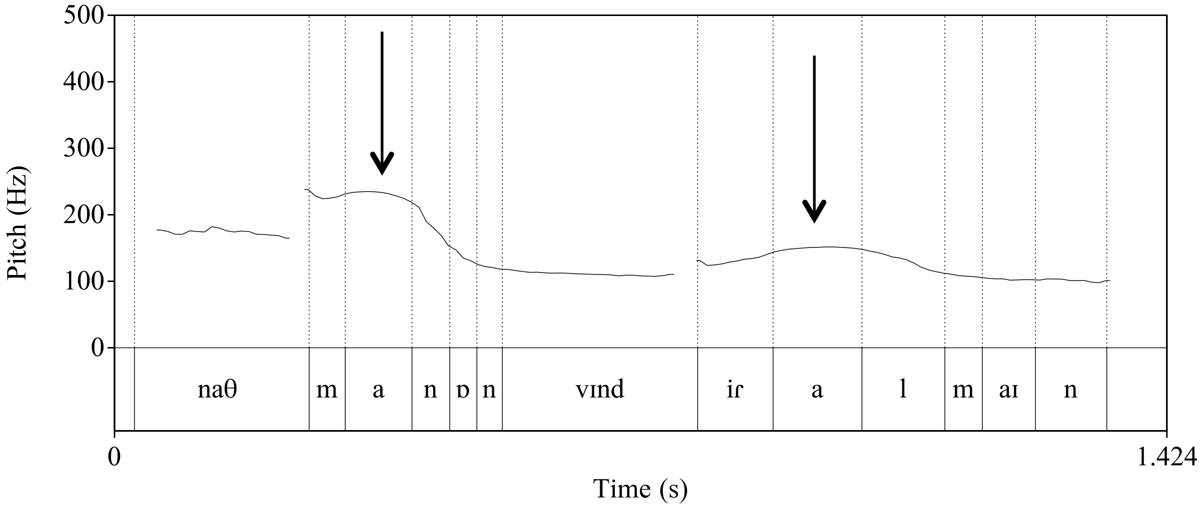


Figure 4: F0 contour of the statement Wnaeth Manon fynd i'r Almaen. 'Manon went to Germany.'. Vertical lines show the segment boundaries of the accented words 'Manon' and 'Almaen'

Furthermore, the pilot experiment was useful in illustrating the accentability of sentential constituents by the single speaker of Anglesey Welsh. Firstly, in the periphrastic (auxiliary-subject-verb-object) construction, a pitch peak was associated only with the stressed syllables of the subject and object: the non-finite verb did not feature a pitch peak. In example y) below, the accented syllables have been underlined. As can be seen in Figure 5 below, there was no pitch movement on the non-finite verb 'fynd' *to go*.

y) Wnaeth **Ma**non fynd i'r **Al**maen.
do.3S.PAST Manon go.NONFIN to Germany.
Manon went to Germany.

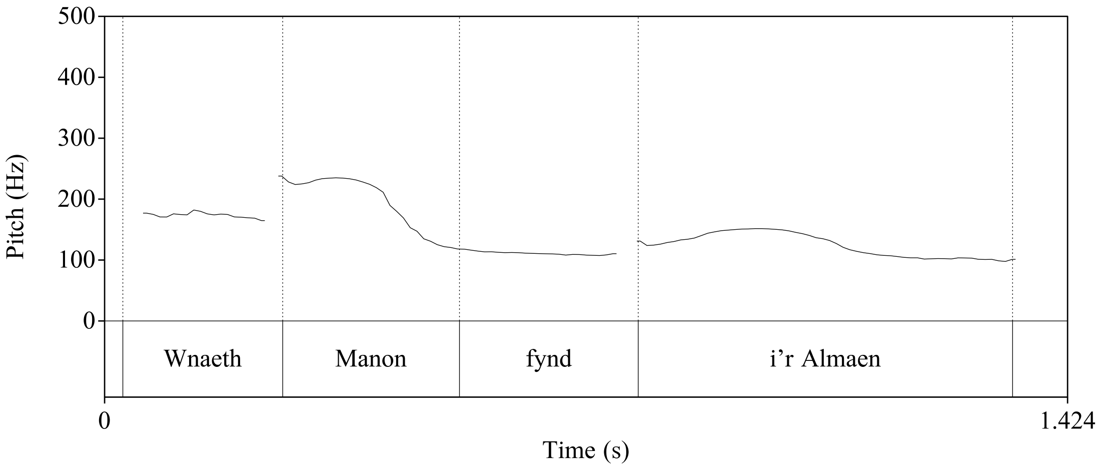


Figure 5: F0 contour of the statement 'Wnaeth Manon fynd i'r Almaen?' 'Did Manon go to Germany?'.

Furthermore, there was also no systematic placement of a pitch accent on the initial finite verb in the few examples where the word order was VSO, as exemplified in Figure 6 below.

z) Aeth **<u>Ma</u>**non i'r **<u>Al</u>**maen.
go.3s.past Manon to Germany.
Manon went to Germany.

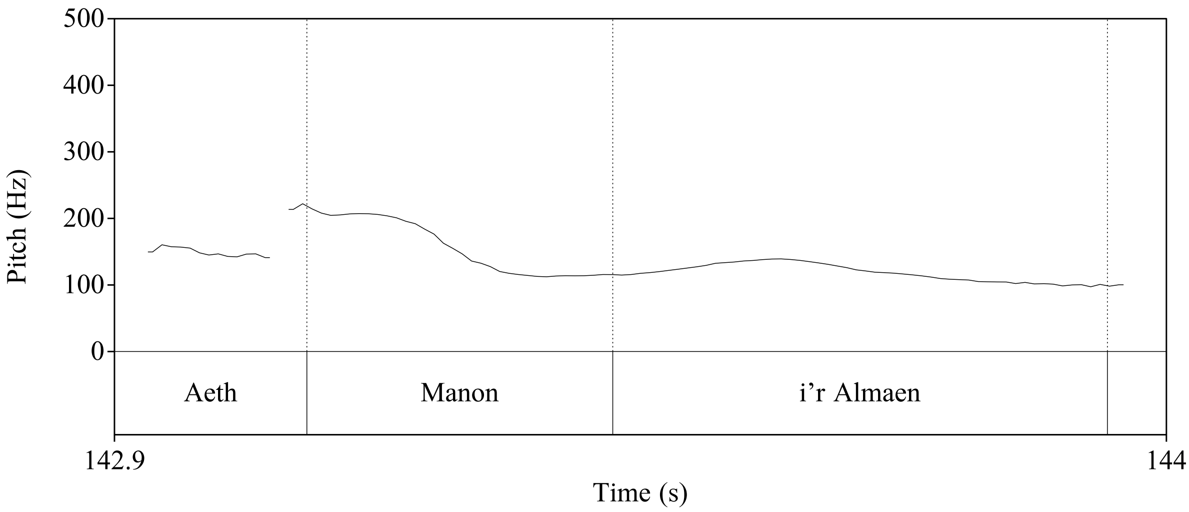


Figure 6: F0 contour of the statement 'Aeth Manon i'r Almaen?' 'Did Manon go to Germany?'.

The pilot study provided valuable information with respect to the design of stimuli for the main reading task, which will be described in detail below.

Dialogue Reading Task

62 target sentences were designed and accompanied in dialogues by a context sentence. The target sentences were designed with the aim of eliciting two pitch accents on the accented syllables of content words, based on the data gathered in the pilot experiment.

The predicted accented syllables were designed to contain mainly sonorant or voiced obstruent segments. Previous research on German (Möbius and Jilka, 2007; Jilka and Möbius, 2006; Demenko et al 2007) and Polish (Demenko et al, 2007) found that several factors pertaining to the segmental make up of utterances can significantly affect the alignment of peaks. In syllables with a sonorant onset, the peak was aligned earliest, while in syllables with a voiceless obstruent onset the peak was aligned later. Peaks in syllables with a voiced obstruent were aligned between the two (Möbius and Jilka, 2007; Jilka and Möbius, 2006; Demenko et al 2007). Therefore, where possible, sequences of sonorant consonant-vowel-consonant were used. In some cases, syllable-initial consonant clusters were included and in two cases, diphthongs were used as the vowel nucleus. Arvaniti, Ladd and Mennen (1998) report that initial consonant clusters do not have a significant effect on the alignment of the peaks and it was therefore considered appropriate to use some clusters in this position.

Following on from the pilot study, a number of the stimuli designed for the main dialogue reading task involved three content words. As previously stated, in the periphrastic construction (auxiliary, subject, verb, object) in the pilot study, the speaker had consistently only produced a pitch accent on the stressed syllables of the subject and object, and examples of these were thus included in the main study (predicted accented syllables underlined):

aa) Wnaeth **El**wyn fynd i'r **ang**ladd?
do.3S.PAST Elwyn go.NONFIN to the funeral?
Did Elwyn go to the funeral?

bb) Roedd **Ma**non yn caru **Wil**.
be.3S.IMP Manon PRT love.NONFIN Wil.
Manon loved Wil.

Similarly, in the pilot, the speaker had not produced a pitch accent on the initial verb in VSO constructions. Thus, the data set was expanded in order to include further examples:

cc) Aeth **Wil** i'r **môr**?
go.3s.past Wil to the sea?
Did Wil go to the sea?

dd) Mi welodd **Ma**non **Wil**.
prt see.3s.past Manon Wil.
Did Manon see Wil?

Furthermore, in order to manipulate further the conditions of tonal clash, a number of constructions also contained just two content words as in:

ee) Mae'r **ei**ra yn **wyn**.
be.3S.PRES snow PRT white
The snow is white.

Following collection of the data from all six speakers in the main dialogue reading task, it was confirmed that they consistently did not accent the non-finite verb in the periphrastic construction with three content words (examples aa) and bb) above). This can be seen in the figure below, there is no visual evidence of a pitch accent on the verb ‘fynd’ *to go* in this example.

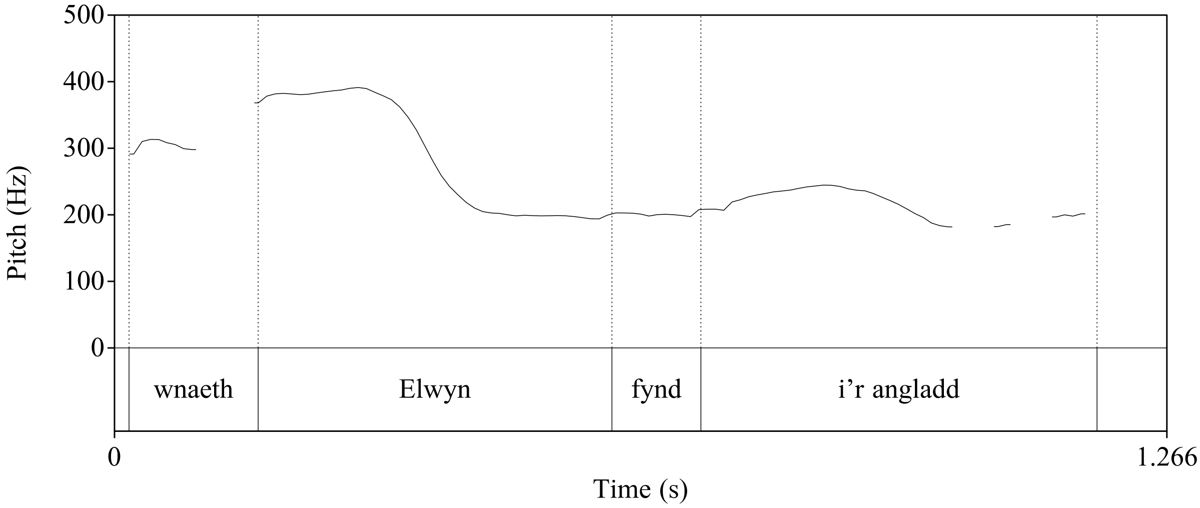


Figure 7: F0 contour of the statement Wnaeth Elwyn fynd i’r angladd? ‘Did Elwyn go to the funeral?’. The vertical lines indicate the word boundaries.

However, where the speaker used for the pilot task had not placed a pitch accent on the initial verb in VSO constructions, the main data collection showed that actually the six speakers varied in whether there was a preference to accent this word or not. In Figure 8 below, there is no evidence of pitch accent placed on the finite verb ‘welodd’, while in Figure 9 there is evidence of a small pitch peak on the verb.

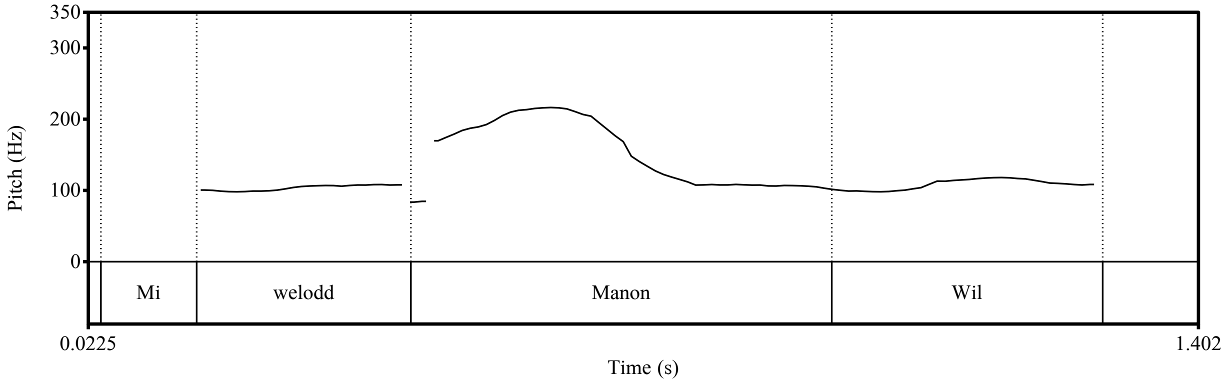


Figure 8: F0 contour of the statement Mi welodd Manon Wil? 'Manon saw Wil' produced by speaker M4G. The vertical lines indicate the word boundaries.

Figure 9: F0 contour of the statement Mi welodd Manon Wil? 'Manon saw Wil' produced by speaker F3E. The vertical lines indicate the word boundaries.

As can be seen in Table 4 below, in the VSO constructions there was a great amount of variation in the placement of pitch accents on the initial verb. For example, speaker F3E (one of the female speakers) never accented the verb, while the other five speakers produced an accent some, but not all of the time.

17 out of 42 of the total VSO utterances elicited from the dialogue reading task contained a third pitch accent. This raises an interesting question about the accentability of constituents in Welsh. In some stress languages like Spanish and Greek, pre-nuclear pitch accents occur on almost all content words, while in other stress languages like English and German, a pitch accent does not occur on every content word (Jun, 2005: 447). A number of studies have pointed out that there are different preferences in the prosodic grouping of syntactic constituents dependent on the language.

For example, Catalan is most commonly grouped as (S)(VO), but "in cases of long branching objects or double-branching objects with non-branching subjects, (SV)(O) phrasings are frequent, due to a tendency to balance the weight and length of the prosodic constituents" (Elordieta et al. 2010: 487). However, in Spanish utterances are mainly grouped as (S)(VO), regardless of constituent length but in Portuguese, (SVO) is the usual phrasing (ibid.).

Table 4 Accented VSO constructions with three content words in the data set collected. Where the number is "2" the speaker consistently accented only the subject and the object of the sentence. Where the number is "3" the speaker consistently accented the subject, object and finite verb form. X refers to occasions where the sentence was omitted for that speaker due to misread examples or creaky voice.

	Number of pitch accents in utterance					
Speaker ID	M1S	F2C	F3E	M4G	M5I	M6O
VSO construction						
Lle welodd Manon Nel where see.3S.PAST Manon Nel *Where did Manon see Nel?*	3	3	2	3	3	x
Aeth Wil i'r mor? go.3S.PAST Wil to the sea *Did Will go to the sea?*	2	2	2	2	2	2
Mi welodd Manon Wil PRT see.3S.PAST Manon Wil *Manon saw Wil.*	3	2	2	3	2	3
Mi welodd Manon Wil? PRT see.3S.PAST Manon Wil *Manon saw Wil?*	3	2	2	2	3	3
Pam oes gan Anwen iar? why be.3S.PRES with Anwen chicken? Why has Anwen got a chicken?	2	2	2	2	3	2
Enillodd Elwyn fil? win.3S Elwyn thousand *Did Elwyn win a thousand?*	2	3	2	x	x	2
Mi ddringodd Manon fynydd PRT climb.3S Manon mountain. *Manon climbed a mountain*	3	x	2	2	2	3
Mi ddringodd Manon fynydd PRT climb.3S Manon mountain *Manon climbed a mountain.*	3	x	2	2	3	3
Total with 2 pitch accent	**3**	**4**	**8**	**5**	**3**	**3**
Total with 3 pitch accent	**5**	**2**	**0**	**2**	**4**	**4**

It appears that for Welsh, some speakers group the verb and subject together forming a prosodic constituent which features only one pitch accent (on the subject). However, in 17 out of the 42 VSO constructions the verb is accented. This may be taken as evidence of a further prosodic constituent here. However, as the proportion of the accented verbs and the overall number of VSO constructions was very small it is not possible to provide an in-depth analysis of prosodic constituency here. This raises an interesting question about the accentedness of sentential constituents that would ideally be followed up with future research.

3.1.1 Sentence type

The variable SENTENCE TYPE was systematically varied in the stimulus set. The four sentence types under investigation were statements (ST), yes-no questions (YQ), wh-questions (WQ) and declarative questions (DQ). Full details of the stimuli used in the dialogue-reading task can be found in Appendix B. Examples of the dialogues for the four target sentence types (in bold) are provided in examples ff) gg) hh) and ii) below.

ff)	Mae pawb yn drist.	'Everybody is sad.'
	Mae Non yn mynd i'r angladd.	'Non is going to the funeral.'
gg)	**Mae Non yn mynd i'r angladd?**	'Non is going to the funeral?'
	Dw i'n synnu am hynny.	'I'm surprised about that.'
hh)	Mae'r plant wedi torri'r ffenest.	'The children have broken the window.'
	Pam doedd Manon ddim yn flin?	'Why wasn't Manon angry?'
ii)	Mae'r plant wedi dechrau bwyta llysiau.	'The children have started to eat vegetables'
	Ydy Wil yn bwyta moron?	'Does Wil eat carrots?'

3.1.2 Temporal constraints

a) Preceding syllables

The number of syllables preceding the prenuclear accented syllable was manipulated for each sentence type in order to test how the prenuclear tonal targets are realised when there is preceding pressure. Table 5 below illustrates the variation in the number of preceding syllables. Each sentence type was manipulated to have 1, 2 and 3 syllables preceding the prenuclear accented syllable, except for wh-questions which feature a question word always followed by a verb. Therefore wh-questions were limited to 2 and 3 syllables preceding the prenuclear accented syllable.

Table 5 Example of variation in the PRECEDING syllables in statements (underlining refers to predicted accented syllables)

Preceding syllables	Example
1	Mae <u>Man</u>on yn caru <u>Wil</u>. be.3S.PRES Manon PRT love.NONFIN Wil. Manon loves Wil.
2	Dydy <u>Man</u>on ddim yn licio <u>mor</u>on. be.3S.PRES.NEG Manon NEG PRT like.NONFIN carrots. Manon doesn't like carrots.
3	Mi ddringodd <u>Man</u>on <u>fyn</u>ydd. PRT climb.3S Manon mountain. Manon climbed a mountain.

b) Tail

The number of syllables following the nuclear accented syllable was manipulated for each sentence type in order to test how the nuclear tonal targets are realised when there is upcoming pressure of the utterance end. The term "tail" (used in the British school of intonation, Chapter 1) is used as a concise label for "the number of syllables following the nuclear accented syllable". As discussed in Chapter 2, Welsh stress falls on the penultimate syllable of content words. It was therefore difficult to achieve any extension of the tail length beyond 1 syllable. The pilot study with one speaker suggested that the addition of another content word to extend the amount of "space" resulted in the production of an additional pitch accent and therefore, although not ideal, it was decided to limit the number of tail syllables to just 1. Table 6 below shows the separation of sentence types into 0 and 1 tail lengths.

Table 6 SENTENCE TYPE and TAIL length occurrences with example (underlining refers to predicted accented syllable in the word)

Sentence type	Tail length	Example
ST	0	Dydy Manon ddim yn licio mêl. be.3S.PRES.NEG Manon NEG PRT like.NONFIN honey. Manon doesn't like honey.
ST	1	Dydy Manon ddim yn licio moron. be.3S.PRES.NEG Manon NEG PRT like.NONFIN carrots. Manon doesn't like carrots.
WQ	0	Pam mae Manon yn mynd? when be.3S.PRES Manon PRT go. NONFIN Why is Manon going?
WQ	1	Pryd mae Manon yn dringo mynydd? when be.3S.PRES Manon PRT climb.NONFIN mountain When is Manon climbing a mountain?
YQ	0	Ydy'r mul yn wyn? be.3S.PRES.NEG donkey PRT white Is the donkey white?
YQ	1	Ydy Manon yn mynd i'r angladd? be.3S.PRES Manon PRT go.NONFIN to DET funeral Is Manon going to the funeral?
DQ	0	Dydy Manon ddim yn licio mêl? be.3S.PRES.NEG Manon NEG PRT like.NONFIN honey Manon doesn't like honey?
DQ	1	Dydy Manon ddim yn licio moron? be.3S.PRES.NEG Manon NEG PRT like.NONFIN carrots Manon doesn't like carrots?

c) Between syllables

The number of syllables between the two accented syllables was also systematically varied, varying from 0 to 5 syllables between the two accents, as exemplified in Table 7. This variation was labelled BETWEEN.

Table 7 Example of variation in the BETWEEN *in yes-no questions (underlining refers to stressed syllables in word)*

Syllables between	Example + gloss	translation
0	Ydy hi'n wlyb? be.3S.PRES it.F PRT wet	Is it wet?
1	Ydy'r <u>mul</u> yn <u>wyn</u>? be.3S.PRES the donkey PRT white	Is the donkey white?
2	Ydy'r <u>af</u>al yn <u>lân</u>? be.3S.PRES the apple PRT clean	Is the apple clean?
3	Ydy <u>Wil</u> yn bwyta <u>mor</u>on? be.3S.PRES Wil PRT eat.NONFIN carrots	Does Will eat carrots ?
4	Ydy <u>Man</u>on yn mynd i'r <u>ang</u>ladd? be.3S.PRES Manon PRT go.NONFIN to the funeral	Is Manon going to the funeral?
5	Ydy <u>El</u>wyn wedi bwyta'r <u>mor</u>on? be.3S.PRES Elwyn PRT eat.NONFIN carrots	Has Elwyn eaten the carrots?

The effect of PRECEDING, TAIL and BETWEEN is investigated in this chapter with regards to the scaling of L and H targets in conditions with plenty of segmental material available to realise intonational targets versus conditions with less space.

Map Task

As briefly described above, one of the data elicitation methods used in this study was a HCRC Map Task (Anderson et al.; 1991) as this technique is less controlled than read speech but still allows more control over the data than fully spontaneous speech. The map task is a game where two participants work together to reach the finish of a map. One participant is the instruction giver and one participant is the instruction follower and their view of the other's map is obscured by a wooden partition. The wooden partition for this task was around 40cm high in order to maintain eye contact between the participants. Four specially designed maps were provided for the participants with landmarks on them (see Figure 10 below). On the instruction giver's map, the route, including the start and finish point was provided (Map A). The instruction follower's map had only the starting point indicated on it (Map B). There were several mismatches between the two maps in each set. The instruction giver was asked to explain the route to the instruction follower. The names of the landmarks on the map were carefully picked by the researcher in order to maximise sonorant segments as in the dialogue-reading task above. Each player was the instruction giver and the instruction follower twice.

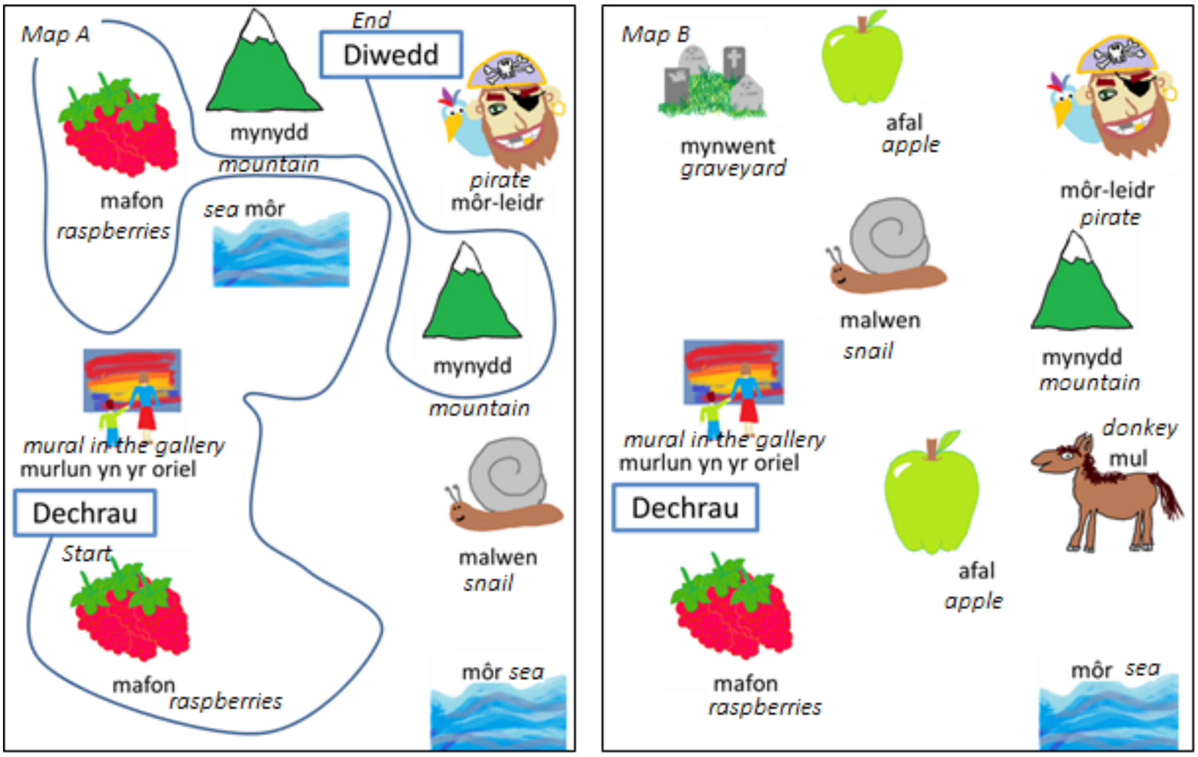


Figure 10: Example of map provided for instruction giver (Map A) and instruction follower (Map B) in the map task (italicised translations have been added)

3.2 Speakers

Basing the study of intonation of a language on the speech of one or two speakers would be less than adequate in an investigation such as this. However, striking a compromise between the number of speakers and the number of repetitions of an utterance under investigation was an important consideration. The speakers for the study were recruited from the immediate local area using a variety of methods: word of mouth, advertisements and posting on the University online notice boards. Five males (average age: 24) and two females (average age: 27) agreed to take part in the study. All seven had attended David Hughes School (Ysgol David Hughes) in Menai Bridge and were raised with at least one parent speaking Welsh to them at home. All had their primary and secondary education through the medium of Welsh (see Appendix C).

3.3 Recording procedure

The reading data were presented as “dialogues” to the speakers via an externally controlled screen inside the booth to minimise excess sound from computers. The dialogues were presented one at a time in random order. An example taken from two of the dialogues is shown in jj) (wh-question) and kk) (yes-no question) below.

jj)

Pam mae'r afal yn feddal?	‘Why is the apple soft?’
Mae o wedi bod yn y bowlen am wythnosau.	‘They’ve been in the bowl for weeks.’

kk)

Ydy’r mul yn wyn?	‘Is the donkey white?’
Nac ydy, mae o'n ddu.	‘No it isn’t, it’s black.’

All instructions were given to speakers in Welsh and it was explained to them that they would be reading two sides of a dialogue as if in a drama. A series of test dialogues were provided in order for the speakers to familiarise themselves with the setup. No specific instructions were given to speakers about intonation; they were instructed to read as naturally as possible and to take as much time as was needed to read the dialogues. Speakers read though all of the dialogues once and after a break were asked to read through the dialogues again, presented in a different random order. The recordings were monitored externally and speakers were asked to re-read any misread dialogues via a sign raised in the window of the recording booth.

The Map Task was introduced to the speakers as a game, which involved the description of a route to another player. A felt tipped pen was provided for the instruction follower to draw their route onto the map. After each game the participants compared their routes and moved on to the next game.

The recordings were made in the recording booth in the School of Linguistics and English Language at Bangor University. The dialogue-reading data were recorded on a Marantz (PMD570) solid-state recorder with an external microphone. The map task was recorded using a different handheld Marantz (PMD620) recorder for ease of placement, set to stereo and placed between the two speakers beside the partition. The recordings were transferred to a computer for acoustic analysis using Praat (Boersma and Weenink, 2013). Further details regarding the acoustic analysis will be described in Section 3.5 below

Speakers were paid a small sum for their participation in the tasks (£6 for the dialogue reading task, £4 for the map task). The participants were recorded between October 2012 and December 2012. The days for data collection were based around the availability of the participants. One pair conducted both the reading task and the map task during the same session but for the other three pairs, one participant performed the reading task on a day prior to the map task and the other participant performed the reading task just before the map task session.

3.4 Elicited data

Dialogue reading task

The two female participants often ended their stretches of speech with creaky voice, which made the labelling and calculations at these points impossible, and therefore these examples were excluded. Some mis-read examples were also excluded from the data set. Table 8 below shows the total number of elicited utterances from each speaker divided by sentence type. One speaker (M7) hesitated a lot through the reading task and for this reason it was decided to exclude all of his data.

Table 8: Total elicited sentences in reading task by SENTENCE TYPE (statement- ST; yes-no questions- YQ, wh-questions- WQ and declarative questions- DQ), and participant (M indicates male, F indicates female)

	M1S	F2C	F3E	M4G	M5I	M6O	Total
ST	16	15	13	16	16	15	91
WQ	14	14	14	13	14	13	82
YQ	4	8	12	12	10	10	56
DQ	16	12	14	16	15	15	87
							316

Map Task

All six speakers whose data were included above took part in the map task with a partner from the remaining participants. All of the pairs knew each other well and Welsh is the language that was reported to be spoken between the pair. There was one female-female pair, one male-male pair and two mixed pairs. As map tasks are less controlled than read speech, it was not possible to control for the type of sentences that were produced by the participants. As a consequence, only five occurrences of declarative question were elicited. For this reason direct comparisons between the read data and the map task data were not made for this sentence type. Furthermore, the elicitations from the map task varied in their length and number of accents. For this reason only *nuclear* tonal targets are presented for the scaling and alignment analyses. Table 9 below shows the elicitations for each speaker from the map task.

Table 9: Total elicited sentence types from map task by participant

	M1S	F2C	F3E	M4G	M5I	M6O	Total
ST	4	8	6	12	5	9	44
WQ	0	1	1	2	0	6	10
YQ	10	1	3	4	3	21	21
DQ	0	0	0	1	3	1	5
							80

3.5 Labelling and Measurements

Measurements of fundamental frequency (F0) and duration were made in Praat (Boersma and Weenink, 2013) using the F0 contour, spectrogram and waveform alongside a TextGrid. Nolan (2006: 438) notes, “an essential task in making an intonation analysis is to divide the speech into intonational phrases”. Firstly, intonational phrases (IPs) were delimited on an interval tier within the TextGrid. Pierrehumbert (1980: 19) suggests that an intonation phrase boundary “can be taken to occur where there is a nonhesitation pause or where a pause could be felicitously inserted without perturbing the pitch contour… However, in normal speech, one finds many cases where the boundary is not marked by a pause, but only by a lengthening of the last syllable in the phrase.” Thus these cues were taken to mark the IP boundaries. This was easiest in the dialogue-reading task as the dialogues presented to speakers had clear syntactic boundaries which co-incided with intonation phrase boundaries in production. However in the Map Task this was more difficult as there were fewer pauses between IPs, and in these cases lengthened syllables were used as cues to IP boundaries following the suggestion of Pierrehumbert (1980).

For the scaling data, the location of prenuclear and nuclear pitch movements was undertaken on a point tier within a Praat TextGrid. Further labels were also added with regards to the segmental string. These segmental labels will be explained in Chapter 4. To begin with, nuclear H located within the accented syllable was demarcated along with the preceding L (occurring at the onset of the accented syllable in most cases). The L following the nuclear H was also labelled. The same process was repeated for any prenuclear H and L targets. The tonal targets were labelled in the HL tier of a TextGrid. The labelled points were:

- Initial - The initial reliable F0 point in the contour
- Low 1 (prenuclear PL1, nuclear NL1)- the lowest F0 value beginning the rise
- High (prenuclear PH, nuclear NH)- The highest F0 value at the peak of the rise-fall movement
- Low 2 (prenuclear PL2, nuclear NL2)- The lowest value following the rise-fall movement
- Final (F)- The final reliable F0 point in the contour. In cases of 0 tail, this often coincided with the end of fall.

An example of a labelled stretch of speech can be seen in the figure below. These objects were relatively easy to identify visually although at times there were microprosodic effects, in which case the next most reliable F0 value point was chosen. A pitch object was produced within Praat to accompany the wav file and the TextGrid label file. The above values were extracted in Hz (linear) with an automated Praat script and these were checked for outliers and corrected where any tracking errors may have occurred. In the figure below there are also labelled segmental landmarks, which will be explained in Chapter 4.

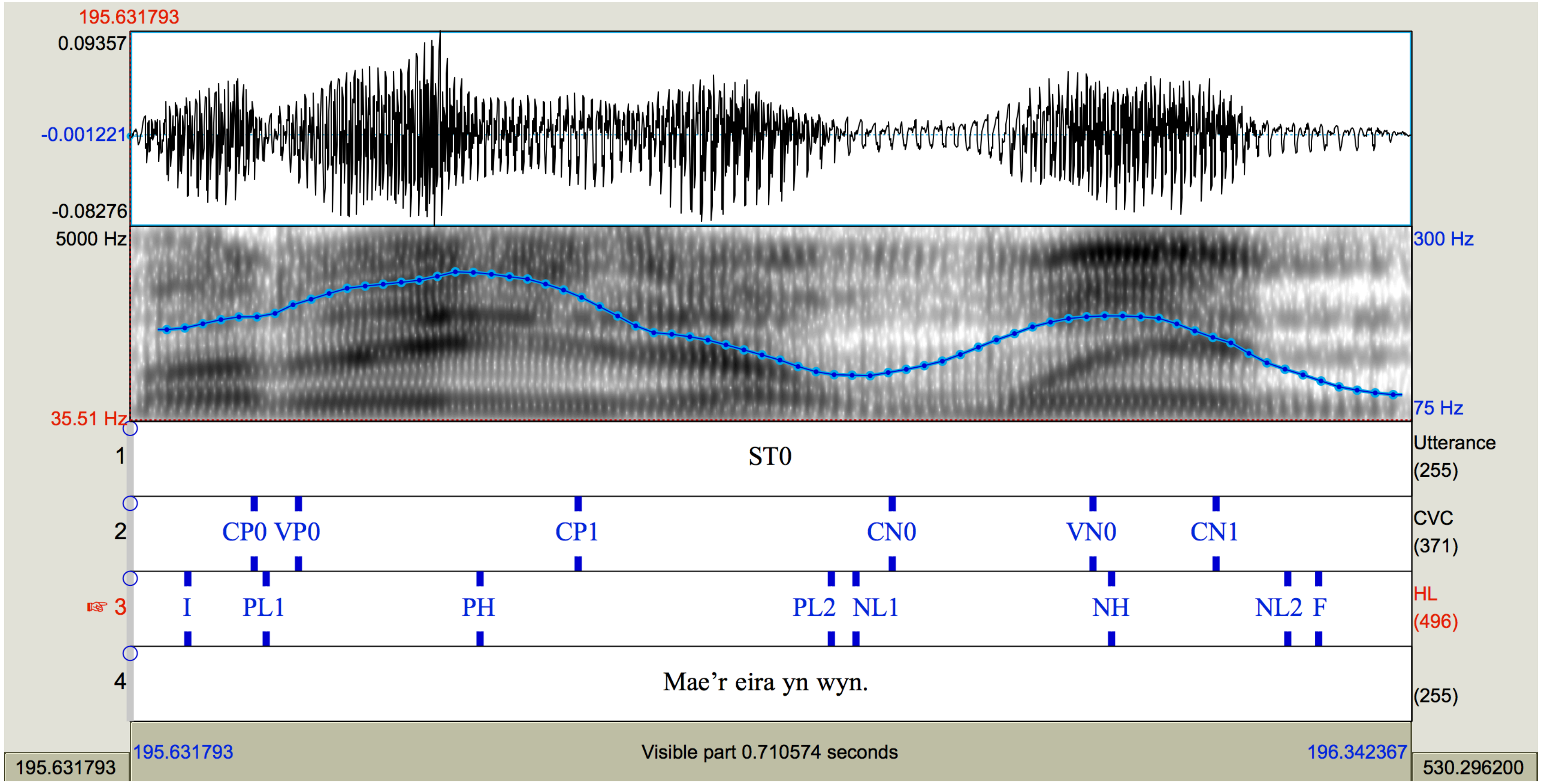


Figure 11: Waveform and F0 contour of the statement Mae'r eira yn wyn *'The snow is white'. The vertical lines in tiers 2 and 3 indicate the segmental string and the labelled F0 points in the contour respectively*

3.6 Calculations

3.6.1 Scaling: Normalisation of Pitch Range

In preparing the data for analysis, an important consideration involved the normalisation of the pitch range of each speaker. Previous studies have shown that "Normalised descriptions [...] show a high degree of inter-speaker agreement" (Ladd, 2008a: 194), while pure values show that "the tonal space can differ conspicuously from one speaker to another and from one situation to another" (Ladd, 2008a: 192). The aim of a normalisation approach is to "abstract away from differences between speakers, paralinguistic effects, and so on, and expresses the invariant characterisations of tones in terms of the *idealised speaker tonal space* that results from this process of factoring out sources of variation" (Ladd, 2008a: 192-3). Therefore, a normalisation method was used for the analysis of scaling, the calculation of which is described below.

The TextGrid extracted the points in linear Hz values. At first, these values were converted into semitones. After further consideration and as Ladd (2008a: 195) points out, we cannot "normalise away from inter-speaker pitch differences merely by transforming F0 data from the linear Hz scale to some other scale, such as the logarithmic semitone scale". Therefore, for the linear Hz values and the maximum and minimum values over the whole read data set were extracted and assigned as the top and bottom of the speaker range, and the individual values for each occurrence were transformed to percentages of these ranges resulting in speaker-specific normalised values on a linear scale (after Mennen, 1999). The data in this chapter are presented in percentages calculated for both the read and map task as described above. However, in Appendix E there is a comparison for each individual speaker of the read speech and map task speech in Hz.

4 Results

This chapter focuses on the vertical scaling of tonal targets in the intonation contour. The first research question addressed in Section 2 was to examine whether the four sentence types (ST, YQ, WQ, DQ) differ in their scaling of valleys and peaks. It is expected that in questions, the L and H tonal targets will be scaled higher than in statements. It is predicted that the more lexico-syntactic marking present in a sentence (e.g. wh-questions), the less intonational marking will be used, following Haan (2002). That is, declarative questions (which are lexico-syntactically identical to their statement counterparts) will feature the highest scaled nuclear pitch accent. Questions which are syntactically identical to their statement counterparts but which feature a differing form of the *to be* verb (yes-no questions) will feature high nuclear accent peaks but the scaling will not be as high as the declarative questions. Finally, the question with the most amount of lexico-syntactic marking (the wh-question which features an *additional* wh-word initially and the remaining information as a relative clause, Awbery, 2009) will be scaled lowest in terms of utterance onset and nuclear accent height.

The final research question examined whether temporal constraints limiting the space available to realise tonal targets affects the scaling. That is, does decreased space affect the height of H and L targets based on 3 temporal constraints: PRECEDING syllables (1,2,3) TAIL (0, 1) and BETWEEN syllables (0,1,2,3,4,5).

The results of this chapter are presented in the following format. Firstly, the read data is considered. The results of the scaling of L1 (the start of the rise), H and L2 (the end of the fall) as are considered with regards to sentence type and temporal constraints, first for prenuclear and then for nuclear position. A comparison of nuclear accent peaks elicited from the map task is provided before a discussion of the findings in Section 5.

4.1 Statistical analysis

The normalised percentage values for the read data (described in Section 3 of this chapter) were subjected to analyses of variance in SPSS. For prenuclear targets, the effect of SENTENCE TYPE, the number of PRECEDING syllables and the BETWEEN SYLLABLES was considered. Thus, a three way MANOVA with three fixed within subject factors: SENTENCE TYPE (four levels: statement, yes-no question, wh-question and declarative question), PRECEDING (three levels: 1, 2, 3) and BETWEEN (0,1,2,3,4,5) was used. For the nuclear targets a three way MANOVA with SENTENCE TYPE, TAIL (two levels: 0, 1) and BETWEEN as independent variables was used. Subsequent one-way analyses of variance were performed on any significant interactions between variables.

The prenuclear and nuclear data were subjected to separate multiple analyses of variance (MANOVA) due to the different sets of independent variable for each position (prenuclear: SENTENCE TYPE, PRECEDING & BETWEEN, nuclear: SENTENCE TYPE, BETWEEN & TAIL). An alpha level of .05 was used for all statistical tests. The results of the above tests are summarised below but full results of the statistical tests can be found in Appendix D.

The Map Task data set was small (n = 75) and thus statistical comparison with the read data were not undertaken. All comparisons between the read and map task data in this thesis are presented graphically. As mentioned in Section 3.4 above, only nuclear accents were considered in the comparison between the read and map task data.

4.2 **Dialogue Reading Task**

4.2.1 **Scaling of Prenuclear targets**

Scaling of prenuclear Low 1 (start of rise)

Results of the MANOVA show that the scaling of **prenuclear L1** (the start of the rise) showed a significant main effect of SENTENCE TYPE [$F(3,313) = 19.7$, $p = .001$]. Post-hoc comparisons showed that there were significant differences between all pairwise comparisons over sentence types [p values < .001] except for YQ and DQ [p = 0.626]. As can be seen in Figure 12 below, the scaling of prenuclear L1 is higher in the questions than the statements, with the L1 in WQ scaled highest. There were no significant effects of the temporal constraints (PRECEDING or BETWEEN) on the scaling of this target.

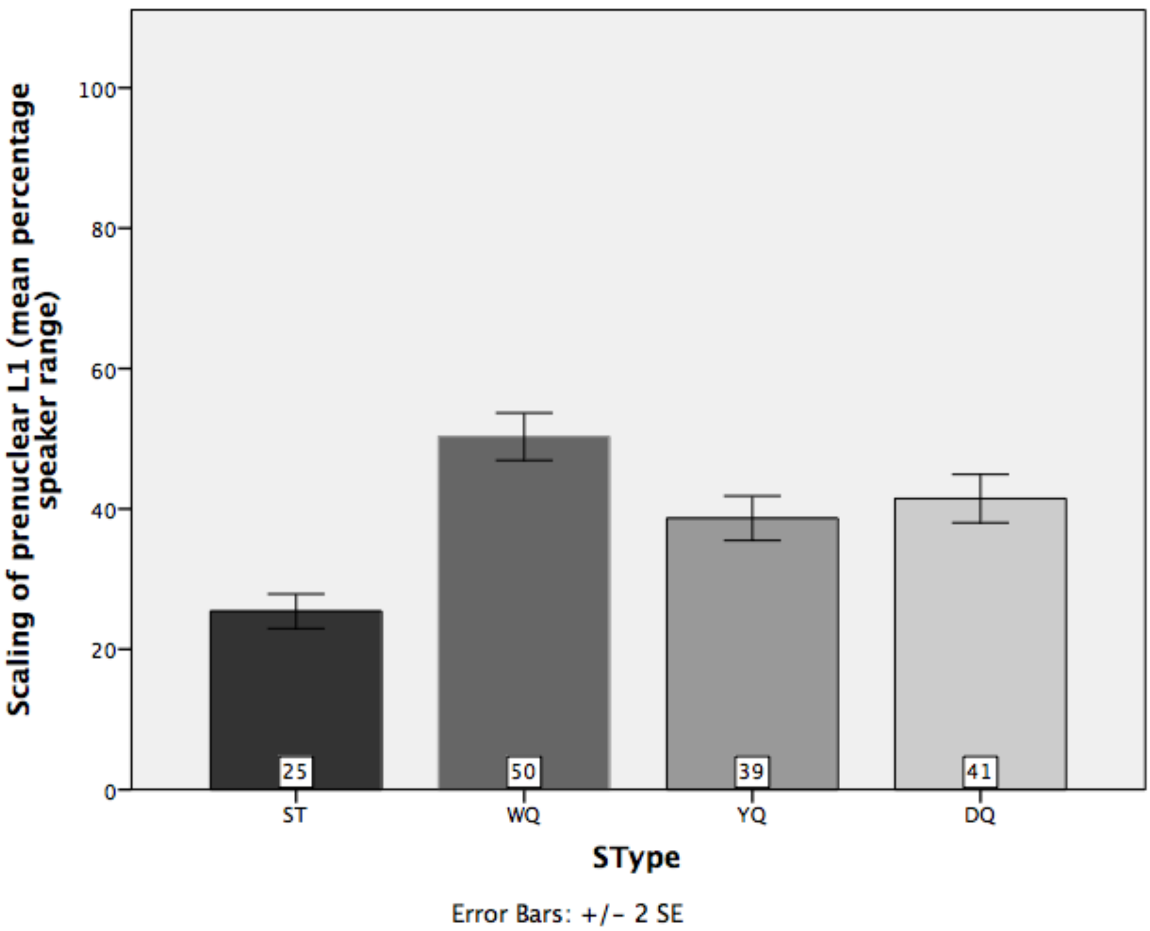


Figure 12: Mean scaling (percentage of speaker range) and standard error of ***prenuclear low 1*** *(L1) as a function of* SENTENCE TYPE

Scaling of prenuclear H

Similar results as those for the scaling of prenuclear L1 were found for the scaling of prenuclear H. Results of the MANOVA show that the scaling of **prenuclear H** was only significantly affected by SENTENCE TYPE [$F(3,313) = 25.9$, $p = .001$]. Post-hoc comparisons showed that there were significant differences between ST and the three question types [p values < .002] and between all question types [p values < .030] except WQ*DQ [$p = .134$]. As can be seen from Figure 13, the lowest scaling of H is found in the statement, and the highest in the DQ and WQ. It can also be seen that prenuclear H in questions in general is scaled higher than in the statements. As with the prenuclear L1 target, there was no effect of PRECEDING or BETWEEN on the scaling of this target.

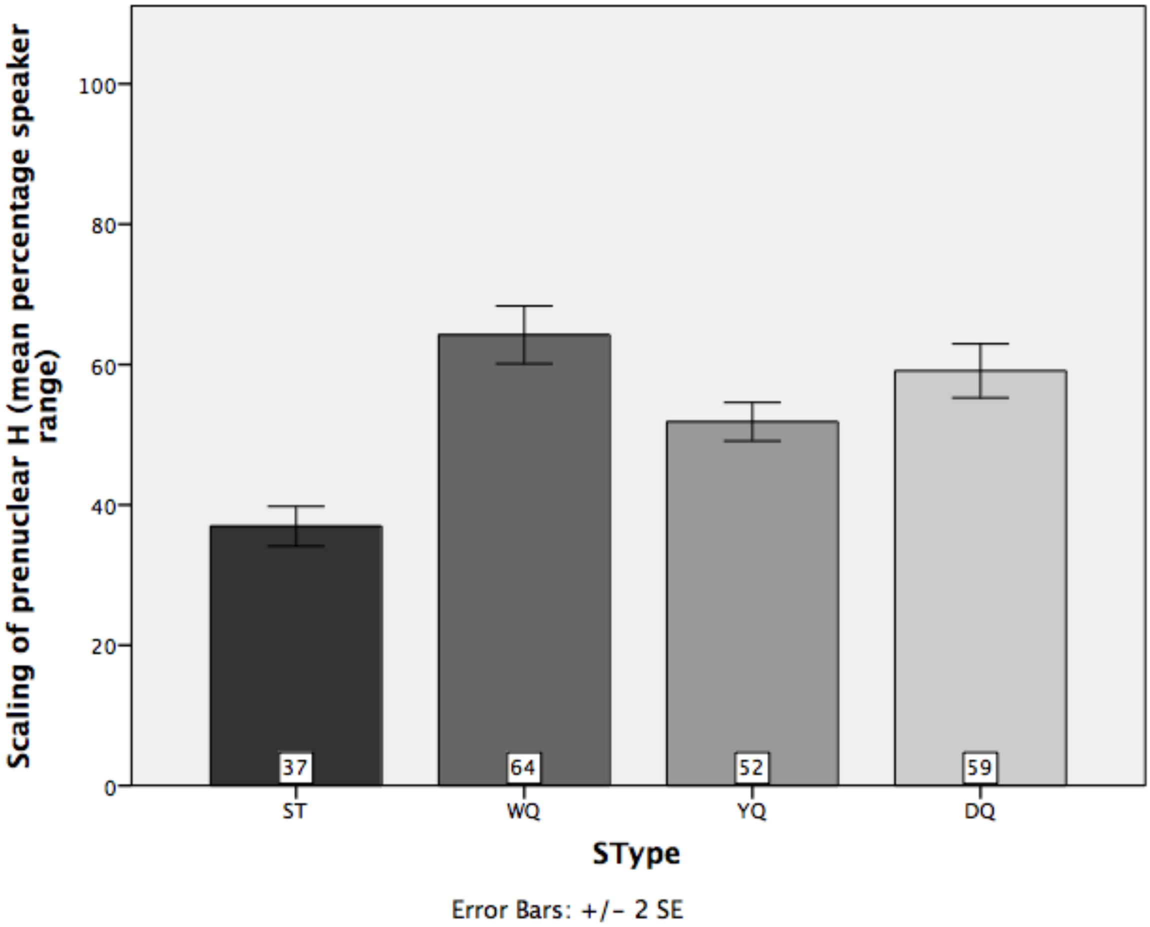


Figure 13: Mean scaling (percentage of speaker range) and standard error of ***prenuclear high (H)*** *as a function of number of* SENTENCE TYPE

Scaling of prenuclear Low 2 (end of fall)

A significant main effect SENTENCE TYPE was also found for the scaling of **prenuclear L2** [$F(3{,}313) = 98.7$, $p = .001$]. All pairwise comparisons of SENTENCE TYPE were significant [p values < .005]. As can be seen in Figure 14, the F0 at the end of the fall in WQs is considerably lower than in YQ and DQ. This is different from the F0 level in WQs at prenuclear L1 and H, which are scaled at the same level or higher than the DQ. This will be further considered in the discussion section at the end of the chapter. Furthermore, there was no significant effect of PRECEDING or BETWEEN on the scaling of this prenuclear L2 target.

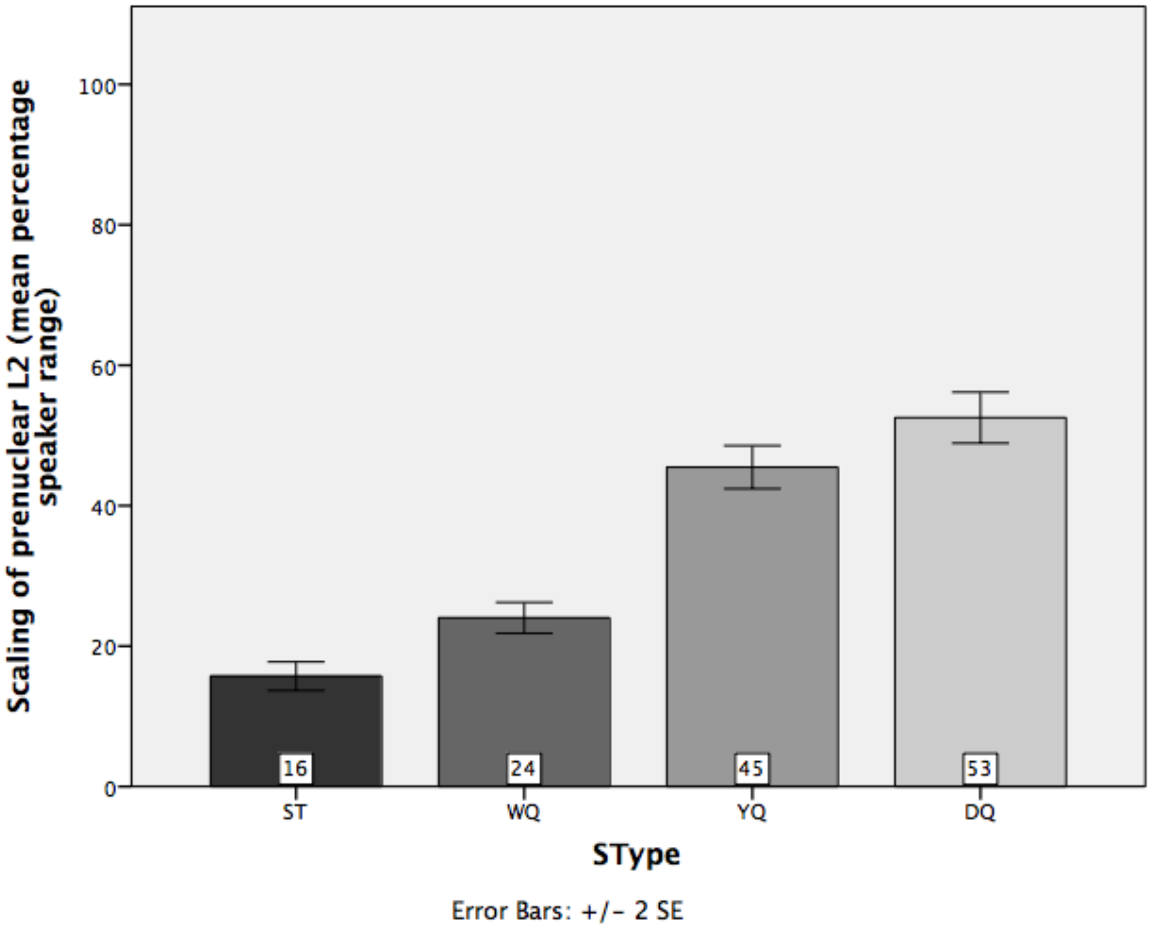


Figure 14: Mean scaling (percentage of speaker range) and standard error of ***prenuclear low 2 (L2)*** *as a function of* SENTENCE TYPE

4.2.2 **Scaling of Nuclear targets**

Scaling of nuclear Low 1 (start of rise)

As for the scaling of **nuclear L1**, the results of the MANOVA show that there was a significant main effect of SENTENCE TYPE [$F(3,308) = 156.7$, $p = .001$], but there was no effect of BETWEEN or TAIL on the scaling of this target. The post hoc test revealed that the scaling of nuclear L1 differs across all sentence type comparisons [p values $< .005$]. For nuclear low, the scaling seems to vary as a function of lexico-syntactic marking for interrogativity, following the order hypothesised WQ<YQ<DQ (after Haan, 2002). As can be seen from Figure 15, it is clear that nuclear low is scaled highest where there is no lexico-syntactic cue to interrogativity (DQ) and lowest in questions where there is most lexico-syntactic marking for interrogativity (WQ).

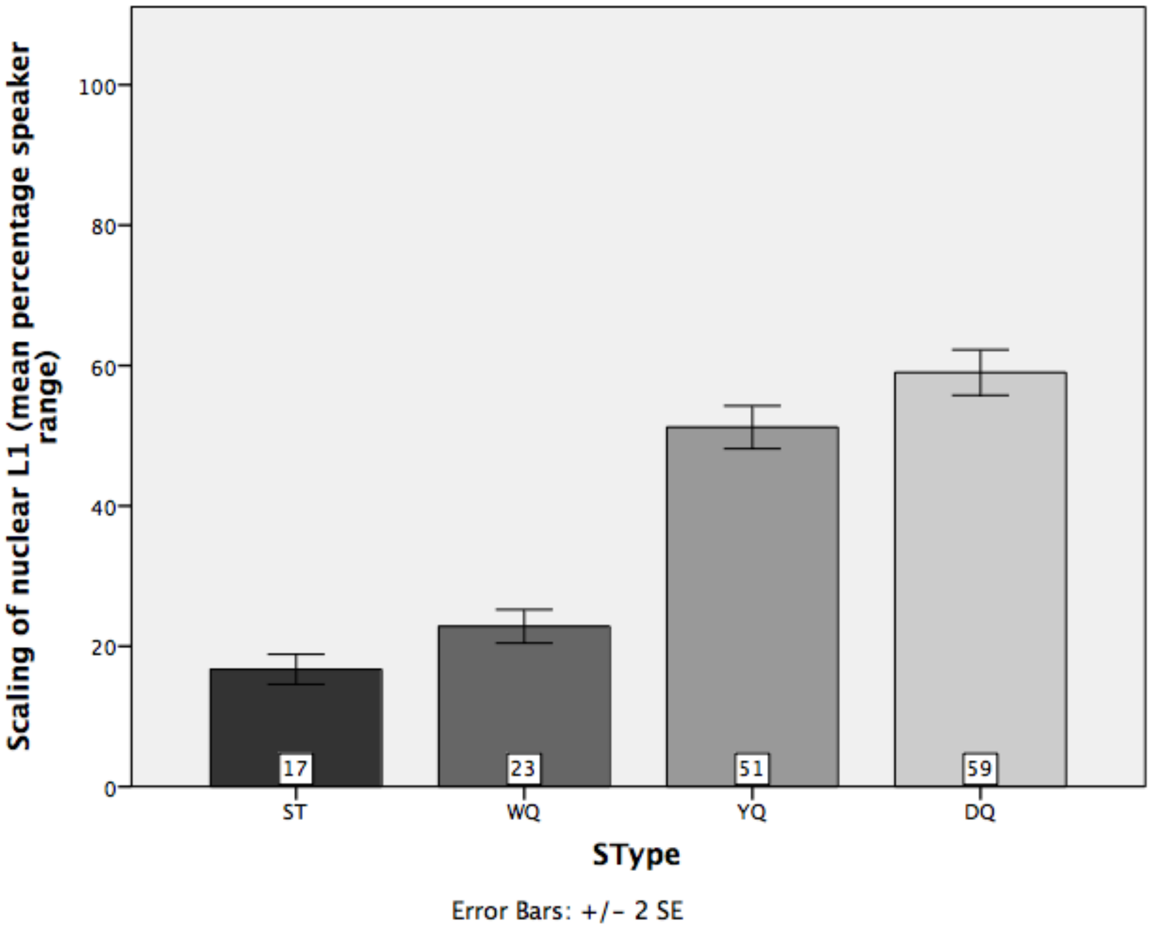


Figure 15: Mean scaling (percentage of speaker range) and standard error of ***nuclear low 1*** *(L1) as a function of* SENTENCE TYPE

Scaling of nuclear H

For the scaling of **nuclear H**, the MANOVA results show that there was a significant main effect of SENTENCE TYPE [$F(3,308) = 185.6$, $p = .001$]. There was no effect of BETWEEN or TAIL on the scaling of this target. The post hoc test revealed that all pairwise comparisons between SENTENCE TYPE were significant [p values < .001]. For the nuclear peaks, the same pattern emerges as found for nuclear L1: the scaling seems to vary as a function of lexico-syntactic marking for interrogativity. As can be seen from the figure below, the nuclear peak is scaled highest where there is no lexico-syntactic cue to interrogativity (DQ) and lowest in questions where there is most lexico-syntactic marking for interrogativity (WQ). This replicates the findings by Haan (2002) for Dutch. A further discussion of these results will take place in Section 5 below.

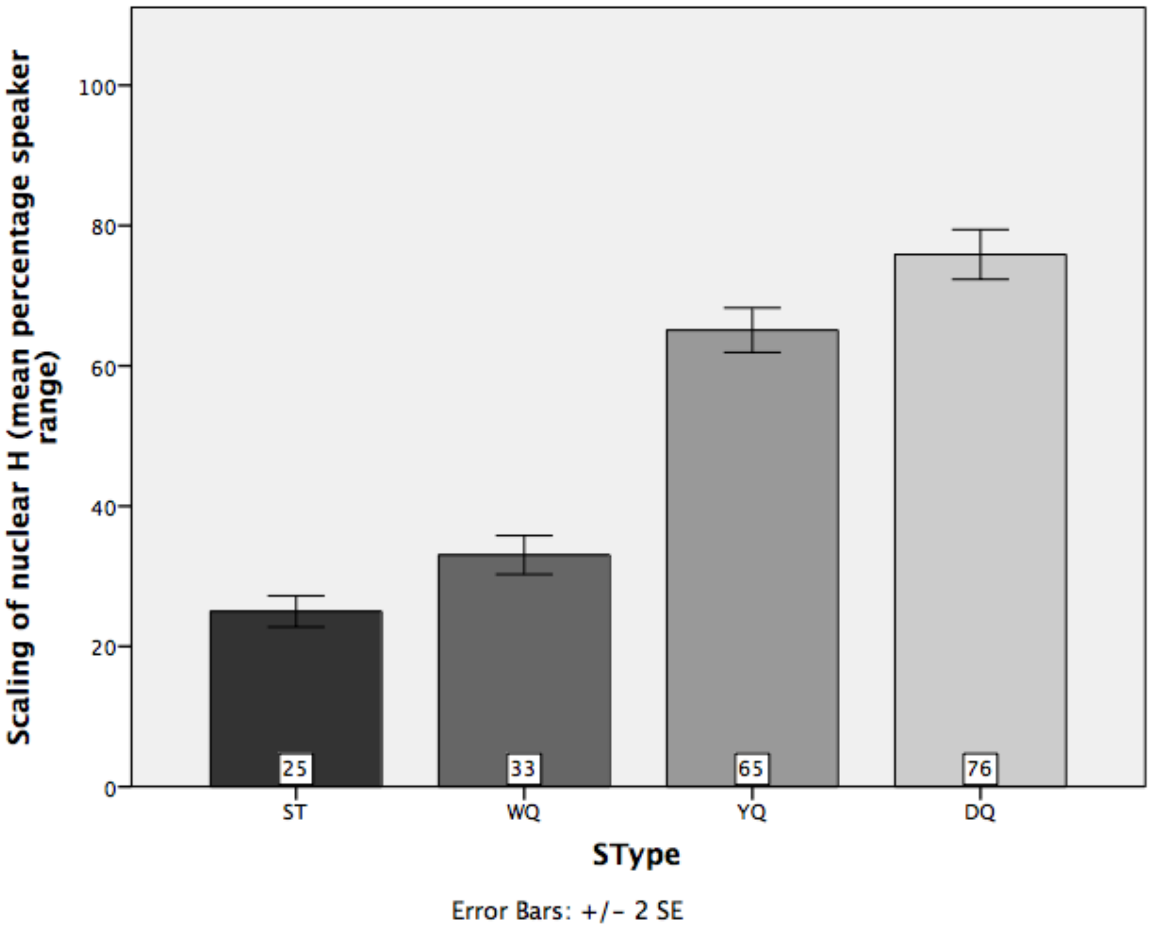


Figure 16: Mean scaling (percentage of speaker range) and standard error of ***nuclear high*** *(H) as a function of* SENTENCE TYPE

Scaling of Nuclear L2 (end of fall)

For **nuclear L2**, only a significant main effect of SENTENCE TYPE was found [$F(3,308) = 20.155$, $p = .001$] (there was no effect of BETWEEN or TAIL). Post hoc tests indicated that scaling of L2 was significantly different between all sentence types [p values < .001] except for ST*WQ [p = .77] and YQ*DQ [p = .599]. As can be seen from Figure 17 below, ST and WQ are realised around the same height (16-18% of speaker range) and DQ and YQ occur at a much higher level.

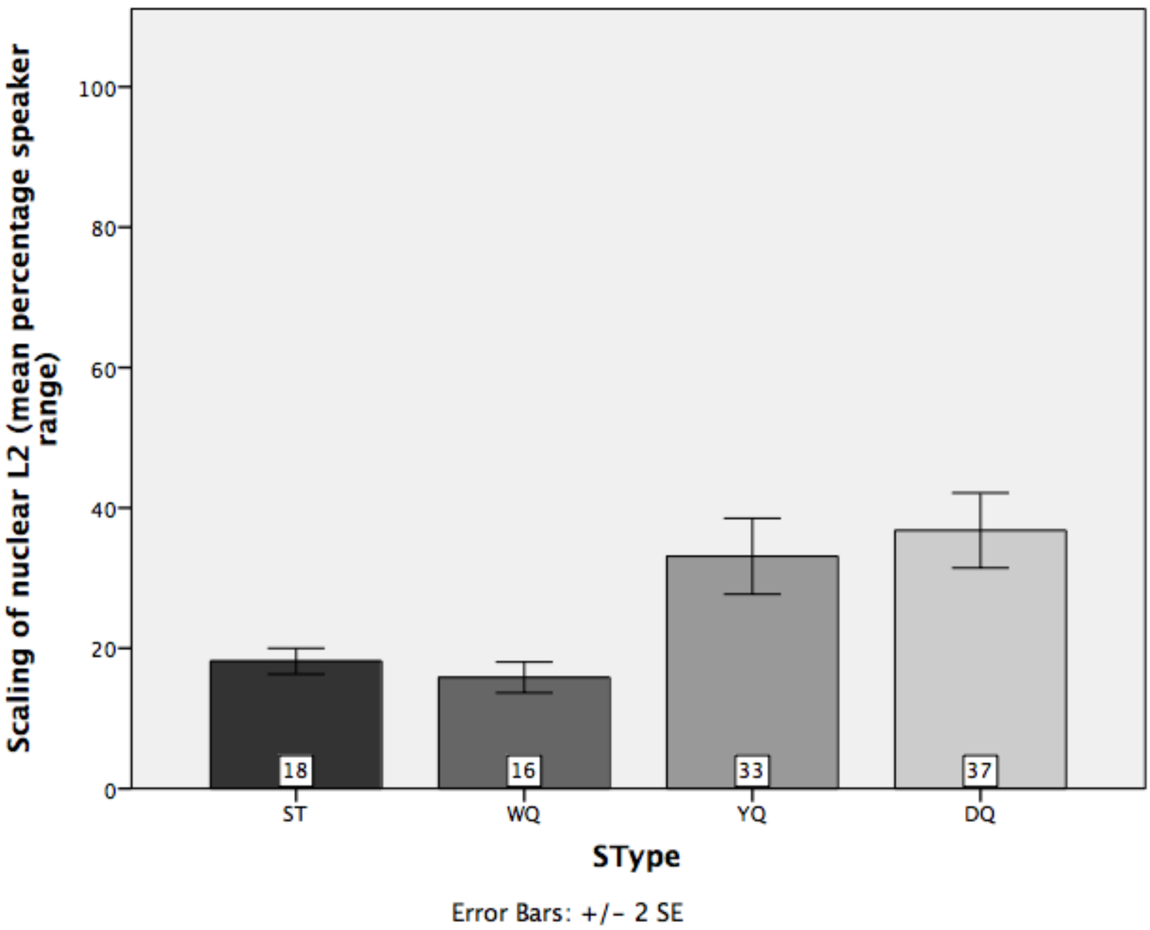
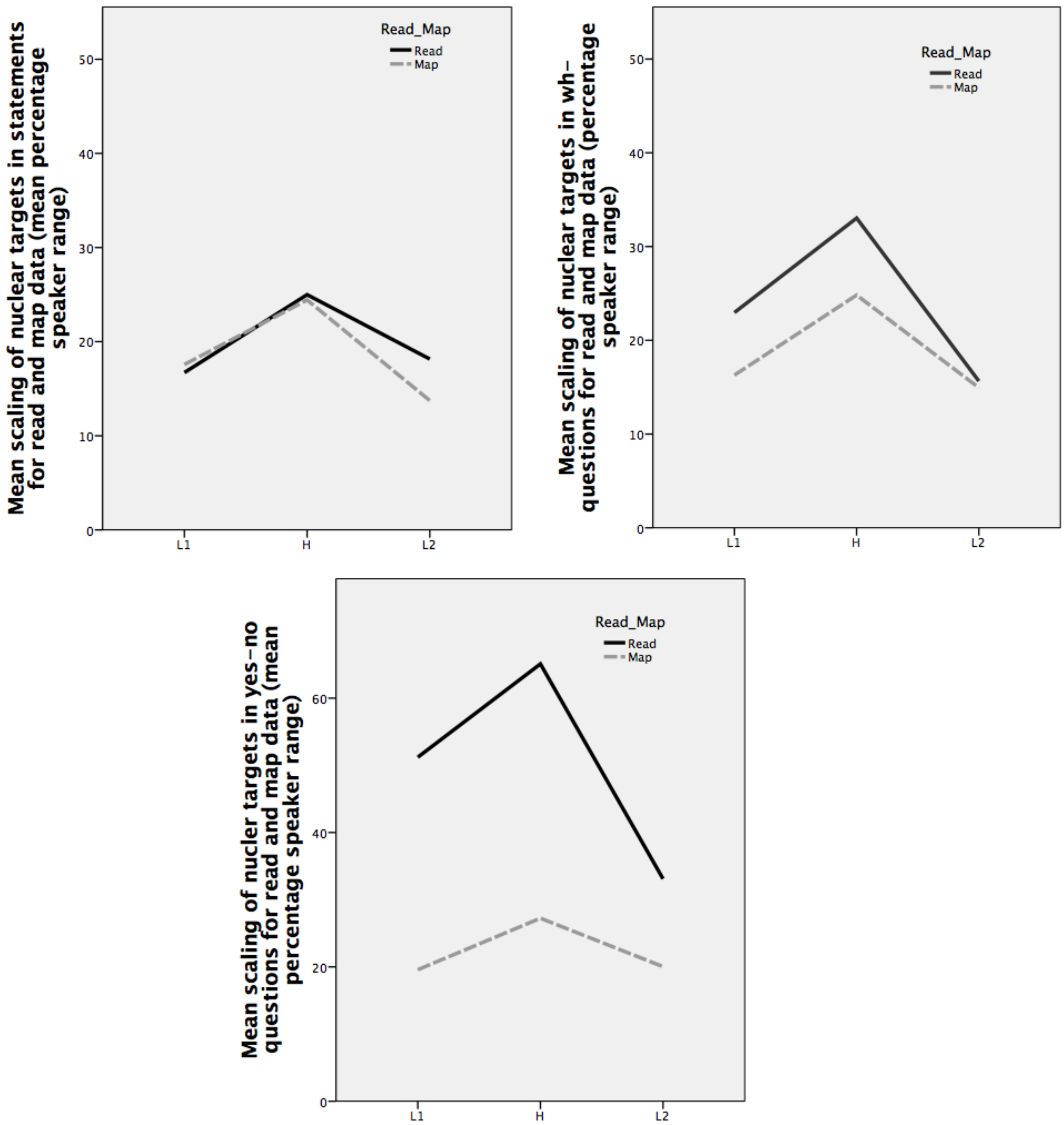


*Figure 17: Mean scaling (percentage of speaker range) and standard error of **nuclear low 2 (L2)** as a function of* SENTENCE TYPE

4.3 Map Task

As can be seen from Figures 18, 19 and 20 below, the scaling of nuclear L1, H and L2 by elicitation method is similar in the statements and the wh-questions, while the scaling of the targets in the yes-no questions differs.



Figures 18, 19, 20: Mean scaling of nuclear L1, H and L2 in statements (top left), wh-questions (top right) and yes-no questions (bottom centre) as a function of elicitation task (reading task vs. map task) normalised percentage speaker range values

In the figures above, the scaling of L1, H and L2 in statements is virtually identical across the two elicitation types. For the wh-questions, as in the statements, the scaling is similar but the targets appear lower in the map task as compared with the reading task. However, in these graphical comparisons the L1 and H targets in the yes-no questions, the targets appear to be scaled considerably lower in the map task as compared with the reading task.

As discussed in Section 3.6, the map task data were calculated as a percentage of the speaker's range taken from the maximum and minimum values elicited in the reading task. However, some of the map task values were below or above these minima and maxima resulting in negative or greater than 100 percentage values. This may have resulted in inaccurate results being produced through the normalisation method for the yes-no questions. In Appendix E, a comparison of each speaker's data for the read and map task is also presented in linear Hz, showing very similar results. However, the results are fairly similar: the statements and wh-questions are more similarly scaled than the yes-no questions. This difference is attributed mainly to the difference in numbers elicited from the map task as compared with the reading task. There were only a small number of semi-spontaneous sentences produced in the map task. There were only 10 wh-questions, 21 yes-no questions and 44 statements produced in total for the map task, compared to over 300 in total from the reading task.

5 Discussion

The present chapter reported the results of a read production task and a map task designed to test the effect of two factors on the scaling of various points across the intonation contour. The aim of this comparison was to test two research questions investigating whether the scaling of tonal targets was different when a) grammatical function (SENTENCE TYPE) was varied and b) when there was reduced space for the targets to be realised (PRECEDING, BETWEEN and TAIL). This chapter also tested whether similar scaling results were found for different sentence types in the map task data. The results of the experiment largely support the hypotheses set out in Section 2.

Firstly, the results show that SENTENCE TYPE is a significant factor in the scaling of the L and H targets in both prenuclear and nuclear position. The aim of this comparison was to establish whether the scaling of tonal targets varied with the grammatical encoding of interrogativity. Haan (2002) had found that for Dutch, the nuclear accent peak height varied as a function of the lexico-syntactic markers for interrogativity present in the utterance. It was predicted for Welsh, that the least lexico-syntactically marked question type (DQ, which is identical to statements) would feature nuclear accent peaks that were highest in the speaker's tonal space. It was also predicted that the question marked minimally for interrogativity (YQ, optionally marked with a *different* form of the verb) would be realised at a higher level than the most marked question for interrogativity (WQ, marked with an *additional* question word), and that nuclear peaks would be realised lowest overall in statements.

Following Haan's (2002) hypothesis for Dutch, this order was indeed found for the *nuclear* accent peaks. As can be seen in Figure 21 below, the L1 and H are realised in this order, and L2 also differs between the sentence types except for WQ and ST. Two patterns emerge in the figure: one for ST and WQ, and the other for DQ and YQ.

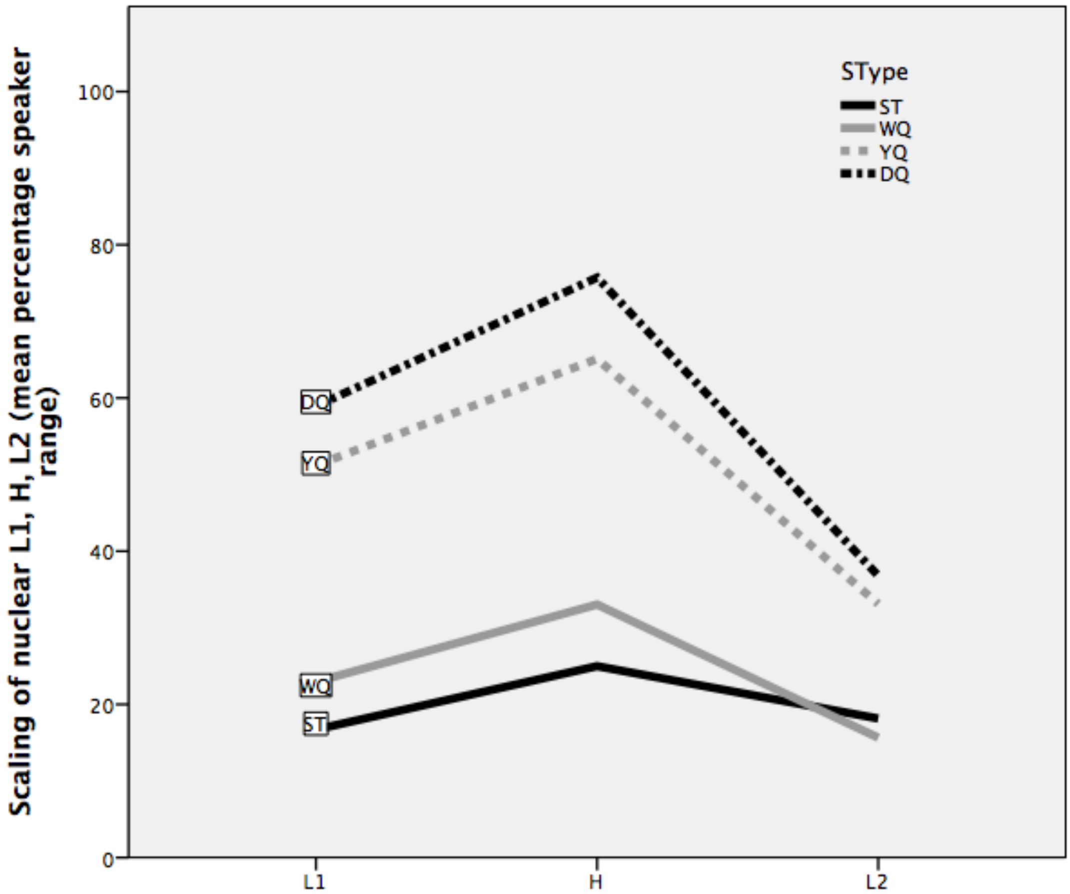


Figure 21: Scaling of **Nuclear *L1, H and L2*** *as a function of* SENTENCE TYPE

Furthermore, comparing the scaling of tonal targets produced via the reading task with the scaling of tonal targets produced via the map task showed that there were fairly similar patterns in statements and wh-questions. However, when comparing the data from the map task with the dialogue-reading task for yes-no questions, there was a noteworthy difference. The comparison of the map task and read data could have been inaccurate due to the normalising approach, but when comparing raw Hz values the discrepancy in the yes-no questions remained. The most probable reason for these significant differences is the very small amount of data elicited from the map task on which the averages were based. The overall data collected from the map-task was around a tenth of the size of the full reading data due to incomplete or dysfluent intonational phrases which were excluded from the analysis. Within-speaker variation would not be well represented in the averaging of these small numbers and the means would be less accurate than with a larger data set. Ideally collecting a much larger data set (more repetitions of the map task per person) or a data set based on a different semi-spontaneous method could remedy this situation.

For the *prenuclear* tonal targets, SENTENCE TYPE also significantly affected the scaling of L1, H and L2 for the reading task. Subsequent analysis showed that at L1 and H, the WQ was scaled highest, as can be seen in Figure 22 below. Due to the fact that question words in Welsh are short monosyllables and often feature a voiceless stop or fricative (pwy, pryd, lle), measurements of pitch were not taken on the question word. However, perceptually the question word in Anglesey Welsh sounds non-prominent compared with the high pitched accented syllable of the subject, which immediately follows the question word. The H target in wh-questions is the highest of all of the tonal targets across all four sentence types in this position. However, as can be seen in Figure 22 below, at this point of the utterance we see that the pitch drops drastically down to the L2 target, nearly at the same level as the lowest sentence type (the statement). The scaling of the L1 and H targets in prenuclear position did not follow the order WQ<YQ<DQ but it is evident that the questions are higher than the statements overall.

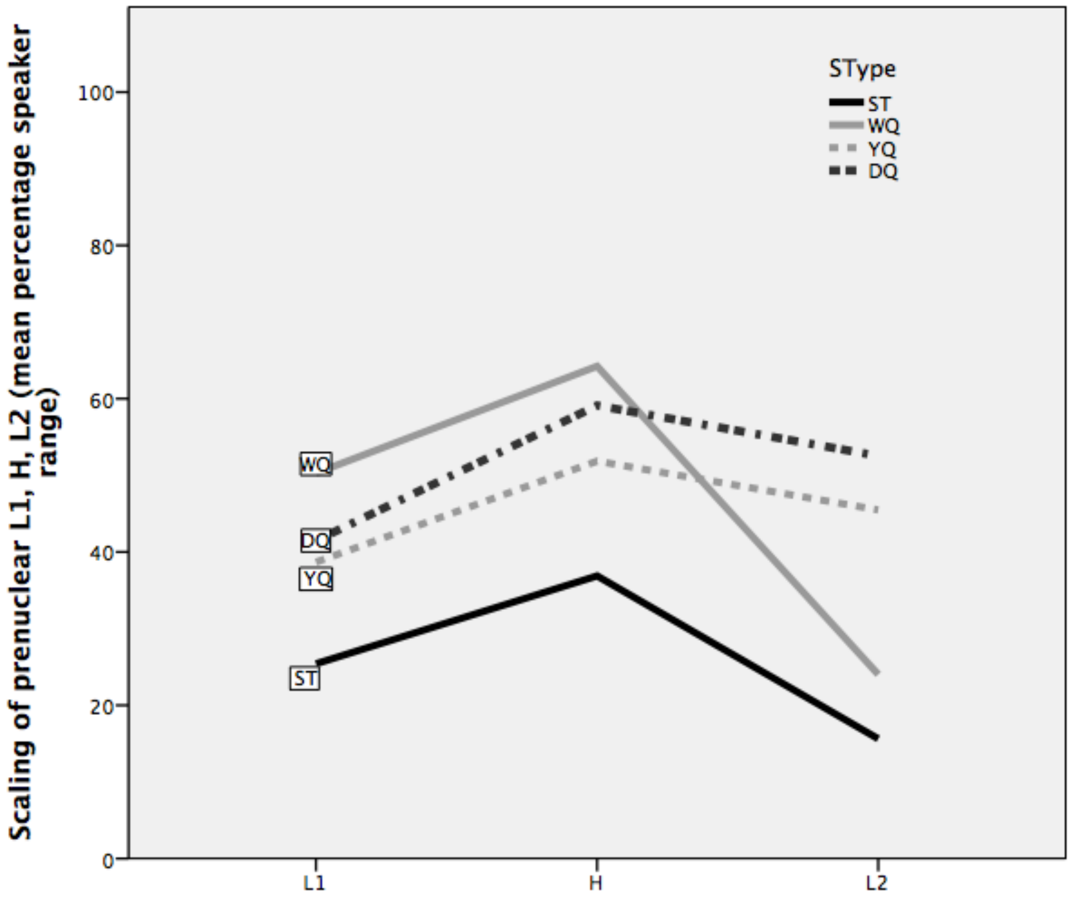


Figure 22: Scaling of **Prenuclear** ***L1, H and L2*** *as a function of* SENTENCE TYPE

For both prenuclear and nuclear tonal targets, the amount of space available for accents to occur (by reducing the number of syllables between accentable syllables, reducing the preceding syllables and reducing the tail) was not found to significantly affect the height of the highs and lows in either the prenuclear or nuclear tonal targets. There was no significant difference in the height of nuclear L1, H and L2 with regards to the number of syllables between accents. This suggests that tonal undershoot as found by Arvaniti et al. (1995, 1998) and Prieto (2005) is not a method utilised by these Anglesey Welsh speakers in order to compensate the realisation of the tonal targets in conditions of tonal clash. Arvaniti and Ladd (2009: 53) write, "most targets tend to show adjustments in alignment rather than scaling" under time constraints. Therefore these independent variables (PRECEDING, BETWEEN and TAIL) will also be investigated in Chapter 4 to their effect on the alignment of the targets.

Chapter Four

Alignment of tonal targets

Chapter 3 and the present chapter are concerned with the phonetic realisation of the tonal targets in the intonation contour. Chapter 3 looked at variation in the realisation of the tonal targets in terms of their scaling. This vertical scaling of the prenuclear and nuclear tonal targets was found to be affected only by SENTENCE TYPE in Welsh. The present chapter focuses on the temporal coordination of these tonal targets with the consonants and vowels in the segmental string. It is known that this alignment can be "systematically influenced" by a range of factors (Ladd, 2009: 169) such as a) grammatical function and b) temporal constraints. This chapter will investigate the way in which the above factors may influence the temporal alignment of tonal targets.

Section 1 will begin this chapter by reviewing the literature pertaining to variation in the alignment of tonal targets to the segmental string. Research questions arising from consideration of the previous literature are outlined in Section 2. In Section 3 further methodological issues that were not covered in the previous chapter are discussed. The results of the alignment data are presented in Section 4 followed by a discussion in Section 5.

1 Factors affecting the alignment of tonal targets

Much of the work in intonational phonology has focussed on the temporal alignment of L and H targets with the segmental material. The research on alignment has found that the synchronisation of tonal targets with the segmental string occurs in extremely consistent ways. Information about tonal alignment is useful because it can be used to help determine the phonological status of the underlying tones, if for example systematic categorical variation is found (e.g. Pierrehumbert and Steele, 1989; D'Imperio and House, 1997).

As discussed in Chapter 1, the alignment of tonal targets has been relatively widely researched in a range of languages (e.g. Prieto et al., 1995 for Spanish, Arvaniti and Ladd, 1995 and Arvaniti et al. 1998, 2006 for Greek; Grabe, 1998 for German and British

English; Atterer and Ladd, 2004 for northern and southern German; Ladd, Mennen & Schepman, 2000, Schepman, Lickley and Ladd, 2006 and Caspers and van Heuven, 1993 for Dutch; Welby, 2006 for French). A number of these studies found that various variables could affect the temporal alignment of the tonal targets to the segmental string. The following section will discuss a) the encoding of grammatical function and b) restrictions imposed by reducing the syllabic or segmental material available.

1.1 Sentence type

In a number of languages it has been found that grammatical function can be expressed by differences in alignment. That is, pitch peaks and valleys may be aligned earlier or later dependent on the grammatical function of the intonational phrase. For example, D'Imperio (2000) found that for Neapolitan Italian the timing of the high tonal target appears to differ between yes-no questions and statements. More specifically, she found that the H tonal targets were aligned significantly later in the yes-no questions as compared to the statements in a read speech corpus produced by two speakers of Neapolitan Italian.

This distinction was also found to hold in subsequent perception studies. D'Imperio and House (1997) and D'Imperio (2000) resynthesized Neapolitan Italian stimuli to change the alignment of the L and H targets in a rise-fall movement. When the tonal targets were displaced later in time, native speakers of the language were more likely to interpret them as a question, showing that later peaks were taken as perceptual cues to interrogativity by Italian listeners.

Similarly, Makarova (2007) studied the effect of sentence type on peak alignment in Russian. She found that peaks in one-word interrogatives (yes-no questions) were aligned significantly later than in declaratives. In the declaratives the pitch peak was aligned just after the onset of the accented vowel onset but in the interrogatives it was aligned towards the vowel offset. She also found that the height of the pitch peak differed according to sentence type: interrogatives had a higher pitch peak than declaratives. In a further study she tested these findings in a perception experiment. Makarova (2007) resynthesized productions of statement and question into 14 modifications. The 'declarative base' and the 'interrogative base' were modified for both pitch peak height and pitch peak alignment. She found that while the ‘base’ (i.e. the original sentence type of the recording before manipulation) had an effect on perception, the peak height and the peak alignment also significantly affected listeners’ perception of sentence type. Specifically, she found that higher peaks and later peaks were used as a cue to membership in the ‘interrogative’ sentence type.

Evidence from Russian and Neapolitan Italian show that later peaks may be indicative of interrogative (yes-no) question intonation. Both Russian and Neapolitan Italian have lexico-syntactically identical yes-no questions and statements. Makarova found that *both* the scaling and alignment were cues to interrogativity. In Chapter 3 of this thesis it was found that the sentence type of an utterance significantly affected the scaling of tonal targets. However, it may also be possible that the feature ‘later accent peak’ may be used in Welsh to indicate interrogativity.

1.1 Temporal constraints

According to the early work by Silverman and Pierrehumbert (1990), tonal targets may be readjusted under the influence of a number of variables. Specifically, temporal constraints can have significant effects on the alignment of tonal targets. It has been found that tonal clash (that is the upcoming or preceding pitch accents or boundaries) can affect the timing of high and low targets in some languages. In Chapter 3, the effect of tonal clash was investigated with regards to the scaling of tonal targets: it was hypothesised that tonal targets may be undershot (H less high, L less low) in conditions of tonal clash. However, the Anglesey Welsh data show that there was no apparent tonal undershooting in conditions of increased temporal pressure. However, it may be the case that speakers of Anglesey Welsh prefer to re-align the tonal targets (they may be pushed earlier with closer upcoming events or later with closer preceding events). This effect is known as *tonal repulsion* (coined by Bruce, 1977).

Silverman and Pierrehumbert (1990) systematically varied the distance between the prenuclear and nuclear accented syllables in short English utterances. They found the above-described effect of tonal repulsion: the prenuclear accent was aligned earlier in the accented syllable the closer it was to the following accented syllable. Since 1990, work on a number of languages has shown that tonal repulsion can be realised as gradient adjustments in alignment caused by phonetic pressure from a closely adjacent tone or boundary (Ladd, 2008a: 181). A fair amount of research has investigated the proximity of two pitch movements just as Silverman and Pierrehumbert did. For example, Prieto (2005) investigated the effect of tonal clash on the alignment of tonal targets in Catalan. It was found that there were significant adjustments to the alignment in clash contexts in utterances with two pitch accents. Prieto found that "clash contexts trigger a drastic reorganisation of the accents involved, namely, the first valley and peak are placed significantly earlier and the second valley significantly later" (ibid.: 238), reorganisations which are attributed to systematic anticipatory or carryover articulation effects.

Furthermore, the number of syllables preceding a prenuclear accented syllable has been found to affect the alignment of tonal targets. For example, Dalton and Ní Chasaide (2005) investigated the effect of anacrusis (the number of syllables preceding a prenuclear accented syllable). They found that in one (Inis Oirr) dialect of Irish the peak is aligned earlier where there are unstressed syllables preceding the prenuclear accented syllable then when there are no unstressed syllables. Similar results have been found for English by Farrar and Nolan (1999) who found a leftward drift in the location of the H accent peak when the number of syllables preceding the prenuclear accented syllable was increased.

The number of syllables following a nuclear accented syllable at the end of an utterance has also been shown to affect the alignment of tonal targets in a number of languages. This was investigated in the early paper by Silverman and Pierrehumbert (1990). They found that the peak in nuclear accents aligns later with an increase in the number of following syllables. This is also a type of tonal repulsion: the nuclear tonal targets are often 'pushed' earlier when there are fewer syllables following the nuclear accent. Arvaniti, Ladd and Mennen (1998) also found that decreasing this number of syllables towards the end of an utterance caused the H in Greek L*H nuclear syllables to be pushed earlier. In a subsequent study by Arvaniti et al (2006), it was found that nuclear low in Greek L*H accents occurred earlier when the nucleus was closer to the utterance end: it was earliest when the nuclear accented syllable was final, later when it was penultimate and latest when the nuclear accented syllable was the antepenultimate syllable of a word. Schepman et al (2006) also found for Dutch that pressure from the upcoming utterance end can cause tonal targets to be "pushed" earlier. Similar effects have been found by Dalton and Ní Chasaide (2005) for Irish nuclear peaks. Dalton and Ní Chasaide

(2005) also found that in the same Inis Oirr dialect of Irish for which adjustments were found in prenuclear accents as a result of the size of the anacrusis, adjustments were also made in nuclear accents based on the presence of postnuclear unaccented syllables. As the number of postnuclear syllables increases, the peak timing migrates rightwards (i.e. is increasingly delayed). However, this was not the case for both of the dialects that were considered in their investigation. The Cois Fharraige dialect of Irish was considered a 'fixed' dialect. Its timing remained unaffected by the presence and/or number of adjacent unstressed syllables.

Taken together, the research suggests that there may be significant adjustments in the alignment of tonal targets based on a) the number of syllables preceding a prenuclear accented syllable, b) the number of syllables between the prenuclear and nuclear accented syllable and c) the number of syllable following the prenuclear and nuclear accented syllable.

2 Hypotheses and research questions

Given the previous research, it is hypothesized that the alignment of accent peaks in Anglesey Welsh may be later in questions than in statements. In fact, peaks *and* valleys in questions may be aligned later than in the statements. In Chapter 3, it was seen that the lexico-syntactic marking of interrogativity influenced the scaling of all 3 tonal targets in prenuclear and nuclear position in a gradable way. It could well be that a similar influence of lexico-syntactic marking could be found for alignment. It is therefore proposed that an adapted version of Haan's (2002) Functional Hypothesis is adopted, which poses that there may be a trade off between the lexico-syntactic indicators of interrogativity and the lateness of a pitch peak. Thus, it is predicted that the more lexico-syntactic marking present in a sentence, the earlier the peaks will occur. That is, peaks may be latest when there is no lexico-syntactic cue for interrogativity, as in declarative questions (DQ). Peaks in yes-no questions (YQ), which are syntactically identical to their statement counterparts but may feature a different form of the *to be* verb utterance initially, will be earlier than in declarative questions. Peaks will be even earlier in wh-questions (WQ) where there is an additional question word to indicate interrogativity and peaks will be earliest in the statements. This effect may also be found for the L targets preceding and following the H targets.

Furthermore, it is hypothesised that the alignment of the tonal targets may vary as a function of the amount of space provided for the tonal targets to occur (e.g. by reducing the number of syllables a) preceding the prenuclear accented syllable (PRECEDING) b) between accented syllables (BETWEEN) and c) following the nuclear accented syllable (TAIL)). It is expected that adjustments to the alignment of tonal targets may occur when there is less space for a pitch movement to be realised. In other words, when the number of preceding syllables is reduced, the prenuclear tonal targets will be pushed later. When reducing the number of intervening syllables between the accented syllables, it would be expected that prenuclear tonal targets might be pushed earlier and nuclear tonal targets may be pushed later. Furthermore, reducing the tail of the utterance may cause the nuclear tonal targets to be pushed earlier.

The following research questions have arisen from the consideration of the above information.

- Do the four sentence types differ in the alignment of the tonal targets (L1, H and L2) in nuclear and prenuclear position?
    - Are tonal targets (H and L) aligned later in questions than in statements, and is this alignment gradable as a function of lexico-syntactic marking?
- Does decreased "space" affect the alignment of highs and lows (PRECEDING: 1, 2, 3; TAIL: 0, 1; BETWEEN; 0, 1, 2, 3, 4, 5)?

3 Method

3.1 Speakers

The same speakers recorded in Chapter 3 were also used here. They were four males (M1S, M4I, M5G, M6O) with an average age of 24 and two females (F2C and F3E) with an average age of 27. A short language background questionnaire was provided to all participants, the details of which can be found in Appendix C. All six participants had been raised with one or two Welsh-speaking parents and had attended the same secondary school (Ysgol David Hughes, Menai Bridge). They had all received their primary education (ages 4-11) and the majority of their secondary education (age 11+) through the medium of Welsh.

3.2 Materials

The recordings described in Chapter 3 also formed the basis for the analysis in this chapter. Two tasks were designed in order to elicit appropriate data: a dialogue reading task and a semi-spontaneous map task.

Dialogue reading task

Within the dialogue-reading task, two features were manipulated in order to investigate the research questions outlined above.

3.2.1 Sentence type

The variable SENTENCE TYPE was systematically varied in the stimulus set. Four sentence types were elicited: statements (ST), wh-questions (WQ), yes-no questions (YQ) and declarative questions (DQ). As described in Chapter 3, all stimuli were accompanied by a context sentence or question e.g. the context sentence *Mae'r plant wedi torri'r ffenest.* 'The children have broken the window' preceded the target wh-question *Pam doedd Manon ddim yn flin?* 'Why wasn't Manon angry?' in the dialogue presented to the speakers. Table 10 below shows the four sentence types elicited and the number of each sentence type designed per speaker. Full details of the stimuli (and the context sentences) presented to speakers can be found in Appendix B.

Table 10 The statement (ST) and three question types: wh-question (WQ), yes-no question (YQ) and declarative question (DQ)) in Welsh

Sentence type	N	Example and gloss	Translation
Statement (ST)	16	Mae Manon yn flin. be.3S.PRES Manon PRT angry	“Manon is angry”
Wh-Question (WQ)	13	Pam mae Manon yn flin? why be.3S.PRES Manon PRT angry	“Why is Manon angry?
Yes-no question (YQ)	14	Ydy Manon yn flin? be.3S.PRES Manon PRT angry	“Is Manon angry?
Declarative Question (DQ)	16	Mae Manon yn flin? be.3S.PRES Manon PRT angry	“Manon is angry?”

3.2.2 **Temporal Constraints**

a) Preceding syllables

The temporal constraints were varied in order to test the alignment of tonal targets in conditions of increasingly reduced space. Thus, the number of unaccented syllables PRECEDING the prenuclear accented syllable was varied (1, 2 and 3) in order to investigate how the prenuclear L1, H and L were realised where there is preceding pressure as a result of reduced syllabic material. Table 11 below shows the variation in the number of syllables preceding the predicted prenuclear accented syllable in statements. There were 1, 2 or 3 syllables preceding the prenuclear accented syllable.

Table 11 Example of variation in the PRECEDING syllables in statements (underlining refers to predicted accented syllables)

Preceding syllables	Example
1	Mae Manon yn caru Wil. be.3S.PRES Manon PRT love.NONFIN Wil. Manon loves Wil.
2	Dydy Manon ddim yn licio moron. be.3S.PRES.NEG Manon NEG PRT like.NONFIN carrots. Manon doesn't like carrots.
3	Mi ddringodd Manon fynydd. PRT climb.3S.PAST Manon mountain. Manon climbed a mountain.

In yes-no questions and declarative questions the number of preceding syllables could be 1, 2 or 3 as with the statements shown in the table above. However, in wh-questions, there was a limit to having 2 and 3 syllables preceding the prenuclear accented syllable due to the presence of the wh-word. The wh-word was counted as a syllable between the utterance edge and the first accented content word. Thus in example a) below, there are two syllables preceding the predicted prenuclear accented syllable.

a) Pryd mae Manon yn dringo mynydd?
when be.3S.PRES Manon PRT climb.NONFIN mountain
When is Manon climbing a mountain?

b) Between syllables

Furthermore, the number of syllables between the prenuclear and nuclear accented syllable was varied in order to test whether reduced space between the prenuclear and nuclear accented syllable would result in adjustments in alignment of the prenuclear L1, H and L2 and the nuclear L1, H and L2. Table 12 below shows the variation in the number of syllables between the prenuclear and nuclear accented syllables in yes-no questions.

Table 12 Example of variation in the BETWEEN *in yes-no questions (underlining refers to stressed syllables in word)*

Syllables between	Example and gloss	translation
1	Ydy'r mul yn wyn? be.3S.PRES the donkey PRT white	Is the donkey white?
2	Ydy'r afal yn lân? be.3S.PRES the apple PRT clean	Is the apple clean?
3	Ydy Wil yn bwyta moron? be.3S.PRES Wil PRT eat.NONFIN carrots	Does Will eat carrots ?
4	Ydy Manon yn mynd i'r angladd? be.3S.PRES Manon PRT go.NONFIN to the funeral	Is Manon going to the funeral?
5	Ydy Elwyn wedi bwyta'r moron? be.3S.PRES Elwyn PRT eat.NONFIN carrots	Has Elwyn eaten the carrots?

c) Tail

Finally, the number of syllables following the nuclear accented syllable was also varied (0, 1) to investigate the alignment of nuclear L1, H and L2 when there is upcoming pressure from the utterance end. Table 13 below shows the variation in tail length across all sentence types.

Table 13 Total numbers of SENTENCE TYPE *and* TAIL *length occurrences with example (underlining refers to predicted accented syllable in the word)*

Sentence type	Tail length	Example, gloss and translation
ST	0	Dydy Manon ddim yn licio mêl. be.3S.PRES.NEG Manon NEG PRT like.NONFIN honey. Manon doesn’t like honey.
ST	1	Dydy Manon ddim yn licio moron. be.3S.PRES.NEG Manon NEG PRT like.NONFIN carrots. Manon doesn’t like carrots.
WQ	0	Pam mae Manon yn mynd? when be.3S.PRES Manon PRT go.NONFIN Why is Manon going?
WQ	1	Pryd mae Manon yn dringo mynydd? when be.3S.PRES Manon PRT climb.NONFIN mountain When is Manon climbing a mountain?
YQ	0	Ydy'r mul yn wyn? be.3S.PRES donkey PRT white Is the donkey white?

YQ	1	Ydy Manon yn mynd i'r angladd? be.3S.PRES Manon PRT go.NONFIN to DET funeral Is Manon going to the funeral?
DQ	0	Dydy Manon ddim yn licio mêl? be.3S.PRES.NEG Manon NEG PRT like.NONFIN honey Manon doesn't like honey?
DQ	1	Dydy Manon ddim yn licio moron? be.3S.PRES.NEG Manon NEG PRT like.NONFIN carrots Manon doesn't like carrots?

Map Task

As described in Chapter 3, a map task (Anderson et al., 1991) was designed to elicit less controlled speech. This method does, however, allow more control over the data than fully spontaneous speech. Within the map task two players work together to find the finish on a specially designed map. The names of the landmarks on the map were carefully picked by the researcher in order to maximise sonorant segments as in the dialogue-reading task above. The four specially designed maps can be found in Appendix A.

One player is the instruction giver who has a start, finish and route provided for them on their map. The other player is the instruction follower who has only the start outlined on their map. The instruction giver was asked to explain the route to the instruction follower and each player was the instruction giver and the instruction follower twice. The two players were separated by a wooden partition but were still able to maintain eye contact with one other.

3.3 **Elicited data**

As described in Chapter 3, a number of examples were excluded from the data set for analysis (due to misreading or presence of creaky voice which made labelling and calculations of the pitch impossible). As a result, 316 utterances were elicited from the speakers in the dialogue-reading task (91 statements, 82 wh-questions, 56 yes-no questions and 87 declarative questions). As the map task was less controlled than the read speech, it was not possible to control for the type or completeness of the sentences elicited. As a result only five occurrences of declarative questions from the speakers were elicited. For this reason, direct comparisons between the read and map task data were not made for this sentence type. Furthermore, the elicitations from the map task varied in their length and the number of accents. For this reason only the nuclear tonal targets are presented in the analyses in this chapter. From the map task, 75 utterances were elicited over all of the speakers (44 statements, 10 wh-questions, 21 yes-no questions). As a result the map-task comparison presented at the end of this chapter would require further research in order to establish whether any differences were in fact due to the elicitation technique or whether they are due to the different task used.

3.4 Segmentation, measurements and calculations

The F0 contour, spectrogram and waveform were used for the acoustic measurements in Praat (Boersma and Weenink, 2013). After the demarcation of the IP, the nuclear syllable was segmented using a point tier within a TextGrid. The syllable onset, vowel nucleus and the consonant following the vowel were marked following the guidelines suggested by Turk et al (2006).

Turk et al (2006: 3) provide practical segmentation criteria for prosodic research by referring to indicators of consonantal constriction events, present in the spectrogram and waveform (rather than relying on, for example, voice onset time or F0 cues). As suggested by Turk et al (2006: 6), the spectrogram was used for first pass segmentation and the waveform was used to fine-tune the location of the boundary. As previously discussed in Chapter 3, mainly sonorant segments had been used in the targeted prenuclear and nuclear syllables although voiced fricatives and voiced plosives were used in some cases. One occurrence of [g] and [d] occurred in the target sentences (in *Mae'r* ***g****wely yn feddal* "The bed is soft" and *Oedd Manon yn* ***d****awel?* "Was Manon quiet?"). In these cases the segmentation criteria suggested by Turk et al (2006) for oral stops were used: the offset of F2 energy from the preceding nasal with a drop in amplitude was used to indicate the point of stop closure and the F2 onset of the following vowel was used as a marker of release (when the burst was not visible on the spectrogram). Two voiced fricatives were also used in the data set in accented syllables: [v] and [ð]. These were a result of initial consonant mutation found in Welsh adjectives preceded by the particle *yn* (e.g. da [da] *good* > yn dda [ən ða] and objects following the subject in VSO constructions (e.g. [m] in *mynydd* [ˈmənɪð] "mountain" > [v] in *Mi ddringodd Manon* ***f****ynydd*. "Manon climbed a mountain").

In these cases the fricative was segmented using the onset and offset of frication noise and the increased spectral energy following the preceding nasal. The oral closure associated with the nasal stops such as [m] and [n] resulted in abrupt changes in spectral energy on the spectrogram as well as a dip on the amplitude (Turk et al, 2006: 12), thus the nasal was demarcated at these points of change. The [w] and [l] segments were most difficult to segment but a consistent method of finding the midpoint between regular formant structure of two adjacent segments was used.

The labels applied to the segmental string in both prenuclear and nuclear positions in the CVC tier of the TextGrid were:

- C0- consonant onset of the accented syllable (CP0 – prenuclear, CN0 – nuclear)
- V- vowel nucleus of the accented syllable (VP0 – prenuclear, VN0 – nuclear)
- C1- consonant following the accented vowel (CP1 – prenuclear, CN1 – nuclear)

Furthermore, the following values (as described in Chapter 3) were labelled in the TextGrid on a separate tier (HL) by hand:

- L1 (start of rise): the lowest F0 value beginning the rise
- H highest F0 value at the peak
- L2 (end of fall): the lowest F0 value following the rise-fall movement

These were labelled in both prenuclear and nuclear position in the dialogue-reading task, but were only labelled in nuclear position for the map task (i.e. at the end of utterances which also occurred at the end of turns). Thus, the labels were PL1, PH, PL2 (prenuclear start of rise, prenuclear peak, prenuclear end of fall) and NL1, NH and NL2 (nuclear start of rise, nuclear peak, nuclear end of fall). It must be noted that the prenuclear L2 (end of fall) and nuclear L1 (start of rise) sometimes coincided (i.e. the end of the fall and the start of the rise were one F0 point), but they could also be some distance away from one another (there was a plateau between the two), and for this reason they were labelled separately.

After extracting time points of these labels using an automated Praat script, the alignment of the L1, H and L2 targets to the segmental landmarks was calculated in milliseconds. The measurements were made for both prenuclear (PL1, PH and PL2) and nuclear targets (NL1, NH, NL2). These duration measurements were exported to SPSS for analysis. The duration measurements are illustrated in Figure 23 below and the calculated distances were the following:

- C0 to L1 (distance of L1 from consonant onset of accented syllable)
- V to H (distance of H from accented vowel onset)
- C1 to H (distance of H from consonant onset of the syllable following the accented syllable)
- C1 to L2 (distance of L2 from consonant onset of the syllable following the accented syllable)

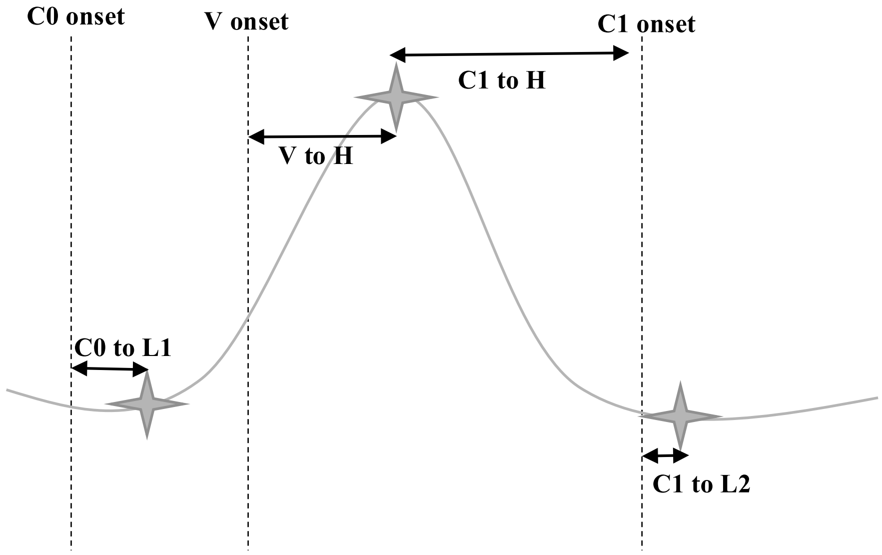


Figure 23: Duration measurements made from elicited points from the TextGrid

4 Results

4.1 Statistical Analysis

The prenuclear and nuclear data were subjected to separate multiple analyses of variance (MANOVA) due to the different sets of independent variable for each position (prenuclear: SENTENCE TYPE, PRECEDING & BETWEEN, nuclear: SENTENCE TYPE, BETWEEN & TAIL). For prenuclear targets, a three way MANOVA with three fixed within subject factors: SENTENCE TYPE (four levels: ST, WQ, YQ and DQ), PRECEDING (three levels: 1, 2, 3) and BETWEEN (0,1,2,3,4,5) was used. Subsequent one-way analyses of variance were performed on any significant interactions between variables. For the nuclear targets a three way ANOVA with SENTENCE TYPE, TAIL (two levels: 0, 1) and BETWEEN as independent variables was used. As before, an alpha level of .05 is adopted for all statistical analyses and details of all statistical tests for this chapter can be found in Appendix F.

4.2 Dialogue Reading task

4.2.1 Alignment of prenuclear targets

Alignment of prenuclear Low 1 (start of rise)

The alignment of **prenuclear L1** from C0 was affected by SENTENCE TYPE [$F(3, 293) = 5.4$, $p = .001$]. Figure 24 below shows that L1 in wh-questions (WQ) was aligned earlier than the three other sentence types and post-hoc comparisons showed that this was statistically significant [p values < 0.014]. As can be seen from the figure, the WQ were aligned on average 38ms before the onset of the consonant in the accented syllable. All other pairwise comparisons were not significant, that is: statements (ST) were not statistically significantly different from the yes-no questions (YQ) and declarative questions (DQ). The other three sentence types tended to align the L1 target just before the onset of the consonantal onset of the accented syllable.

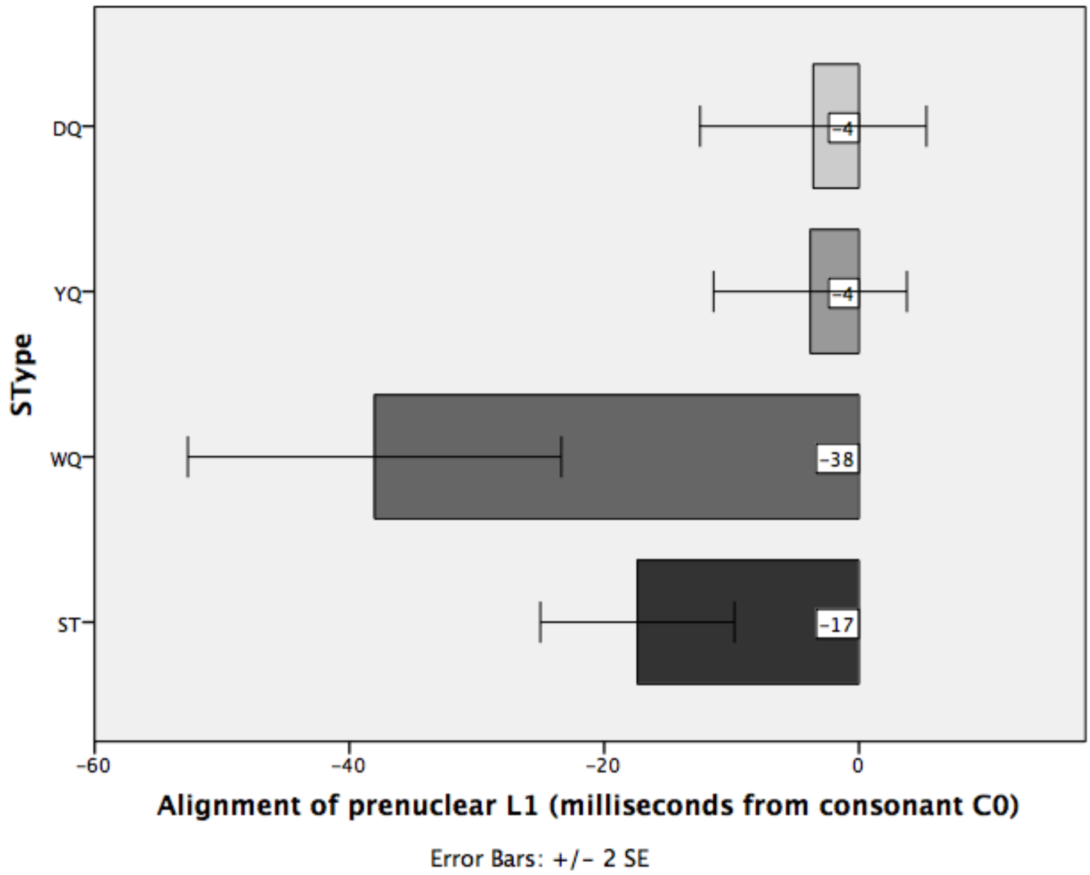


Figure 24: Mean alignment of ***prenuclear L1*** *from onset of accented syllable in ms as a function of* SENTENCE TYPE

For this target, only the SENTENCE TYPE had a significant effect on the alignment of the L1 tonal target and this was stable even in conditions of tonal clash (fewer syllables between the prenuclear and nuclear accented syllables) and proximity to the utterance edge (the number of syllables preceding the prenuclear accented syllable. The other factors PRECEDING and BETWEEN were not significant, full details of which can be seen in Appendix F. Thus, the alignment of prenuclear L1 was stably aligned (although earlier in wh-questions) and was not affected by the proximity of the utterance edge or upcoming nuclear tonal targets.

Alignment of prenuclear H

The alignment of **prenuclear H** was also affected by SENTENCE TYPE for the measure V to H (distance from onset of nuclear vowel) [$F(3, 293) = 5.3$, $p = .001$] and for the measure C1 to H (distance from the accented vowel offset) [$F(3, 293) = 7.6$, $p < .001$]. The pairwise comparison for V to H showed that the only significant difference was between DQ and ST [p = .044], but for the C1 to H measure, the posthoc comparisons showed that there were highly significant differences between ST and DQ [p < .001] and WQ and DQ [p = 0.013]. As it is possible that these differences may have been caused by different durations of the segments in each of the sentence type, it was decided to calculate the alignment of H as a percentage of the vowel duration. The mean duration (and standard error) of the vowel was 95.6ms (3.8) for statements, 95.8ms (4.0) for wh-questions, 91.1ms (3.5) for yes-no questions, and 83.4 (3.4) for declarative questions. Thus, the H aligned 30% of the way through the accented vowel in statements, 44% of the way through the accented vowels in wh-questions, 48% of the way through the accented vowel in yes-no questions and 53% of the way through the accented vowel in declarative questions. A further ANOVA on the alignment of H as a percentage of the vowel confirmed that there was a significant effect of SENTENCE TYPE [$F(3, 311) = 7.1$, $p = .001$]. The post-hoc analysis showed that this difference was only significant between the statements and the declarative questions ($p = 0.001$) and the statements and the yes-no questions ($p = 0.030$). As can be seen from Figure 25 below, alignment appears to be later in the questions than in the statements, providing support for the hypothesis that there may be later alignment in questions than in statements and that this may be later as a function of the lexico-syntactic cues to interrogativity (Haan, 2002).

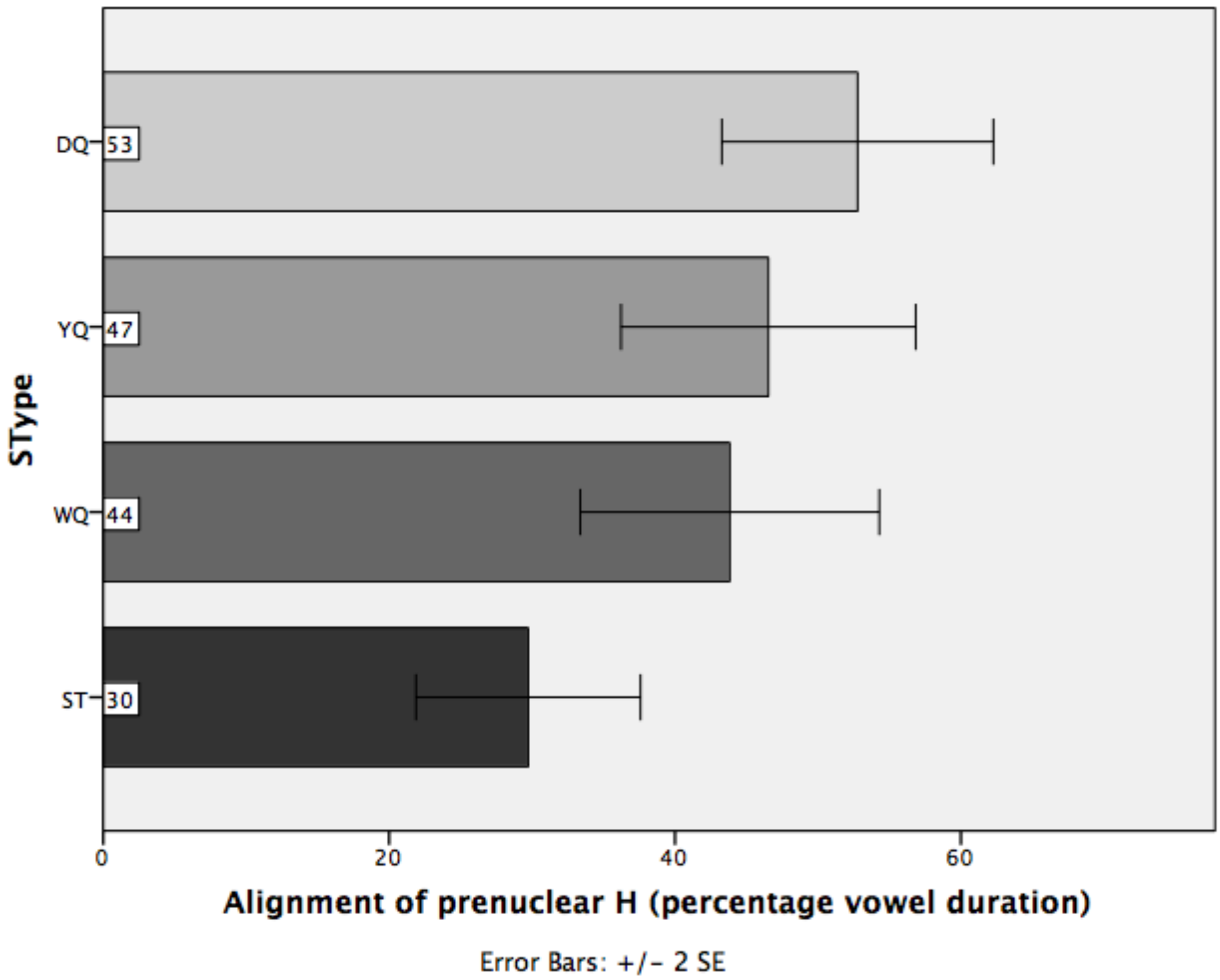


Figure 25: Mean alignment of ***prenuclear H*** *from expressed as a proportion of the accented vowel as a function of* SENTENCE TYPE

There was also a significant effect of the number of between syllables for this measure (percentage of vowel duration), but the effect only just reached significance [$F(5, 311) = 2.3$, $p = .042$]. Subsequent post-hoc analyses showed that there was a significant difference between the 1-between condition and the 2, 3, 4, 5 condition (p values < 0.006). As can be seen from Figure 26 below, the 1 between condition features significantly earlier alignment than these other four conditions. However, the graph below also shows that there was a great amount of variability in the 0 condition, suggesting that in conditions of tonal clash where the prenuclear and nuclear accented syllable are in close proximity that the H may be aligned earlier. However, regardless of the clash condition, the H still aligns within the accented syllable and in general, specifically, it aligns around halfway through the accented vowel.

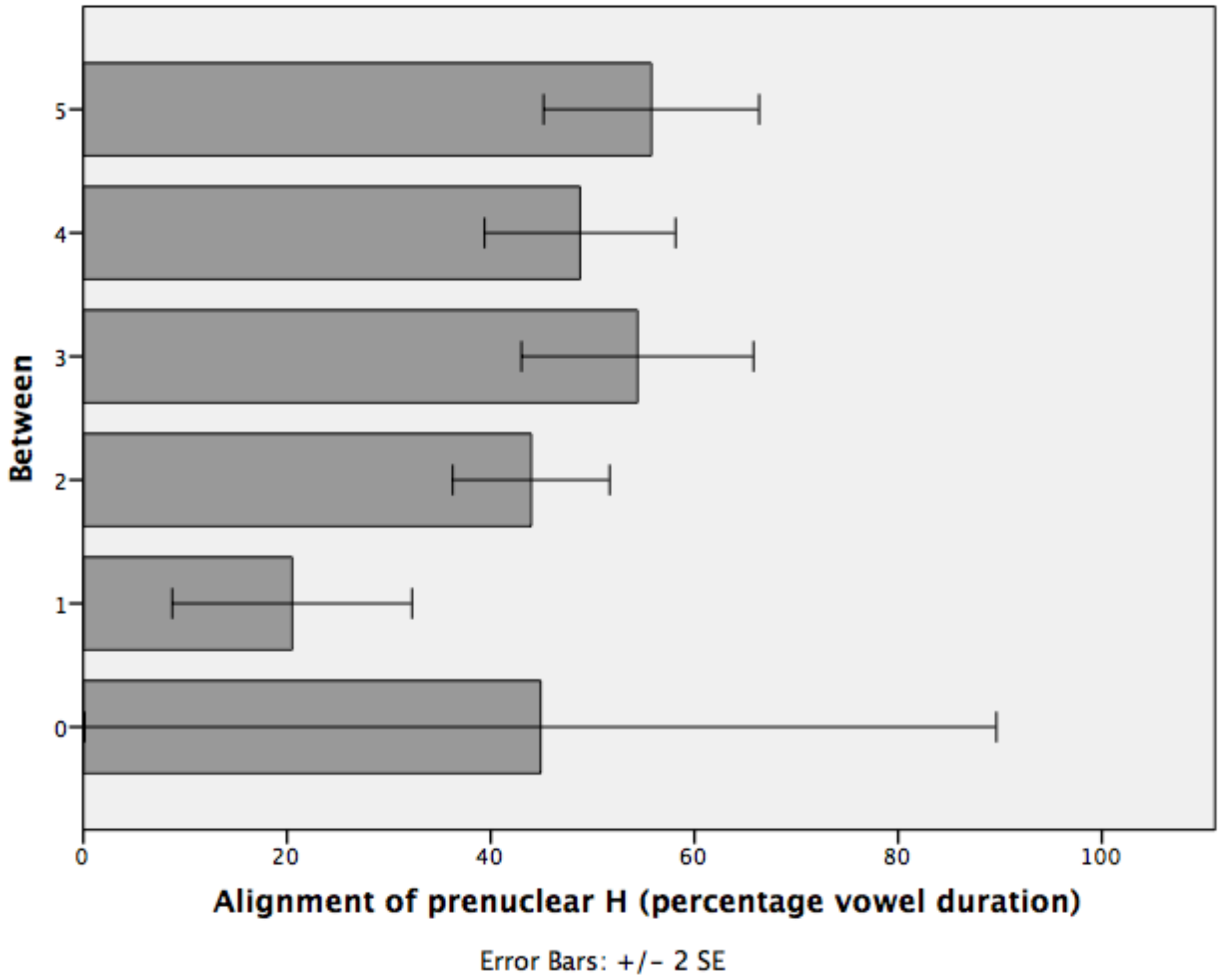


Figure 26: Mean alignment of prenuclear H as a proportion of the vowel duration as a function of BETWEEN SYLLABLES

An interaction was also found between the SENTENCE TYPE and PRECEDING variables [$F(2, 311) = 9.9$, $p < .001$]. Further investigation of this interaction showed that only in yes-no questions was there an effect of preceding syllables. The H tended to align ater when there were 3 syllables preceding the accented syllable than when there was 1 syllable preceding the accented syllable. However, these adjustments were small (see Appendix F for details).

Alignment of prenuclear Low 2 (end of fall)

The ANOVA showed that the alignment of **prenuclear L2** (end of fall) (C1 to L2) was affected by SENTENCE TYPE [$F(3, 293) = 6.9$, $p < .001$] The post-hoc analyses showed that there were significant differences between WQ and all other sentence types [p values = < .014] and between ST and DQ [p = .010].As can be seen in Figure 27, the L2 in wh-questions is aligned much later than in the other three sentence types (illustrating the significant difference present). Furthermore, it can be seen that the L2 aligned 27ms later in statements than in declarative questions.

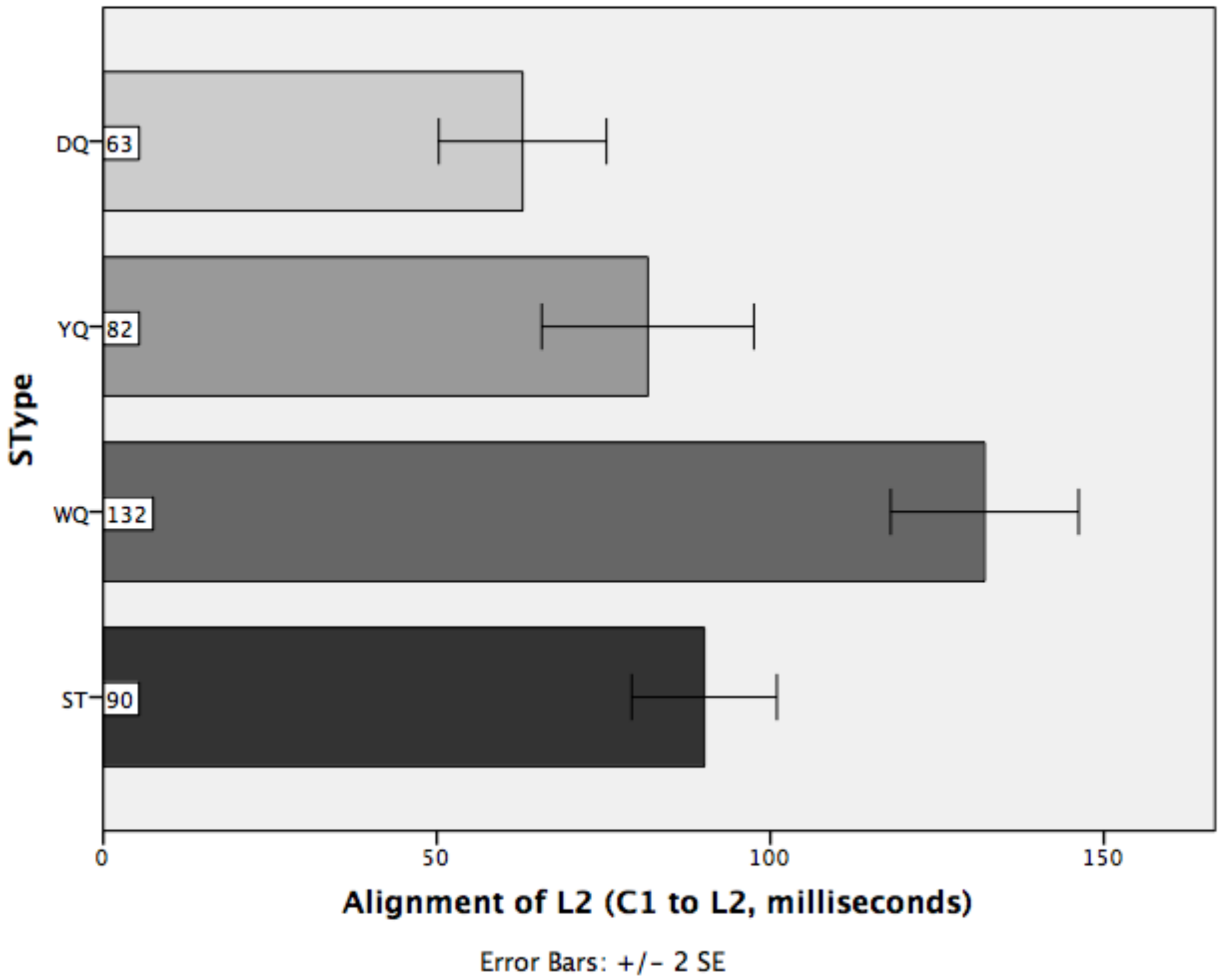


*Figure 27: Mean alignment of **prenuclear L2** from offset of accented vowel (onset of C1 consonant) in ms as a function of* SENTENCE TYPE

Furthermore, there was further variable alignment in the prenuclear L2 as a result of the variable BETWEEN for C1 to L2 [$F(5, 293) = 6.8$, $p < .001$]. The subsequent post-hoc tests show that there were significant differences between 0 and 1,2,3,4,5 and between 1 and 3,4,5. As can be seen in Figure 28, there is a clear pattern of earlier alignment as a function of the number of syllables between the prenuclear and nuclear accented syllables, with a later L2 when there are more syllables available between the prenuclear and nuclear accent.

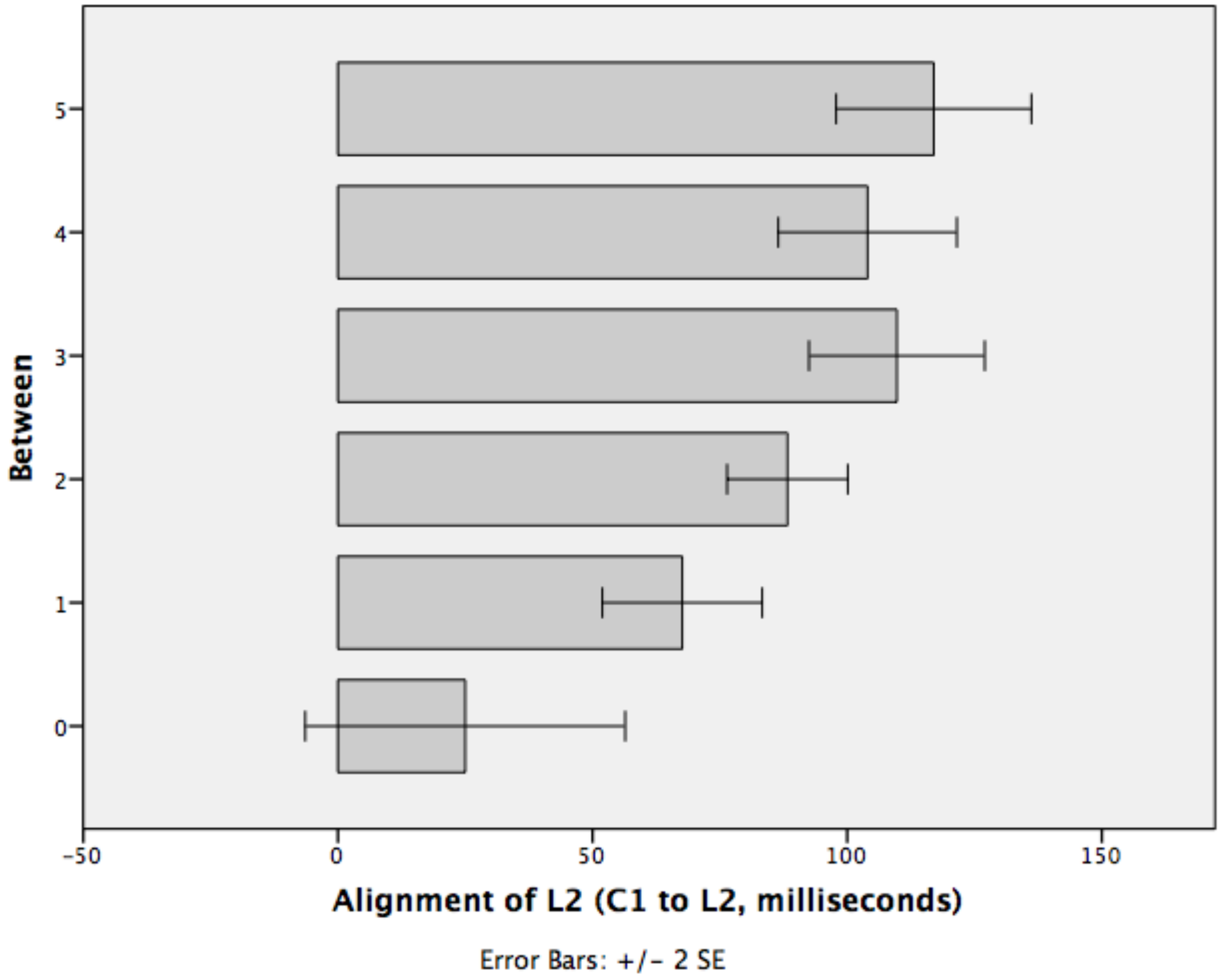


Figure 28: Mean alignment of ***prenuclear L2*** *from onset of accented vowel in ms as a function of* BETWEEN

There was also significant variable alignment of prenuclear L2 as a result of the number of syllables PRECEDING the prenuclear accented syllable [$F(3, 293) = 6.4$, $p < .005$], as can be seen in Figure 29. There was significantly earlier alignment in the 1 syllable preceding condition than in the 2 and 3 syllable condition (p values < .006). That is, with increased proximity to the utterance onset the L2 target was also pushed earlier.

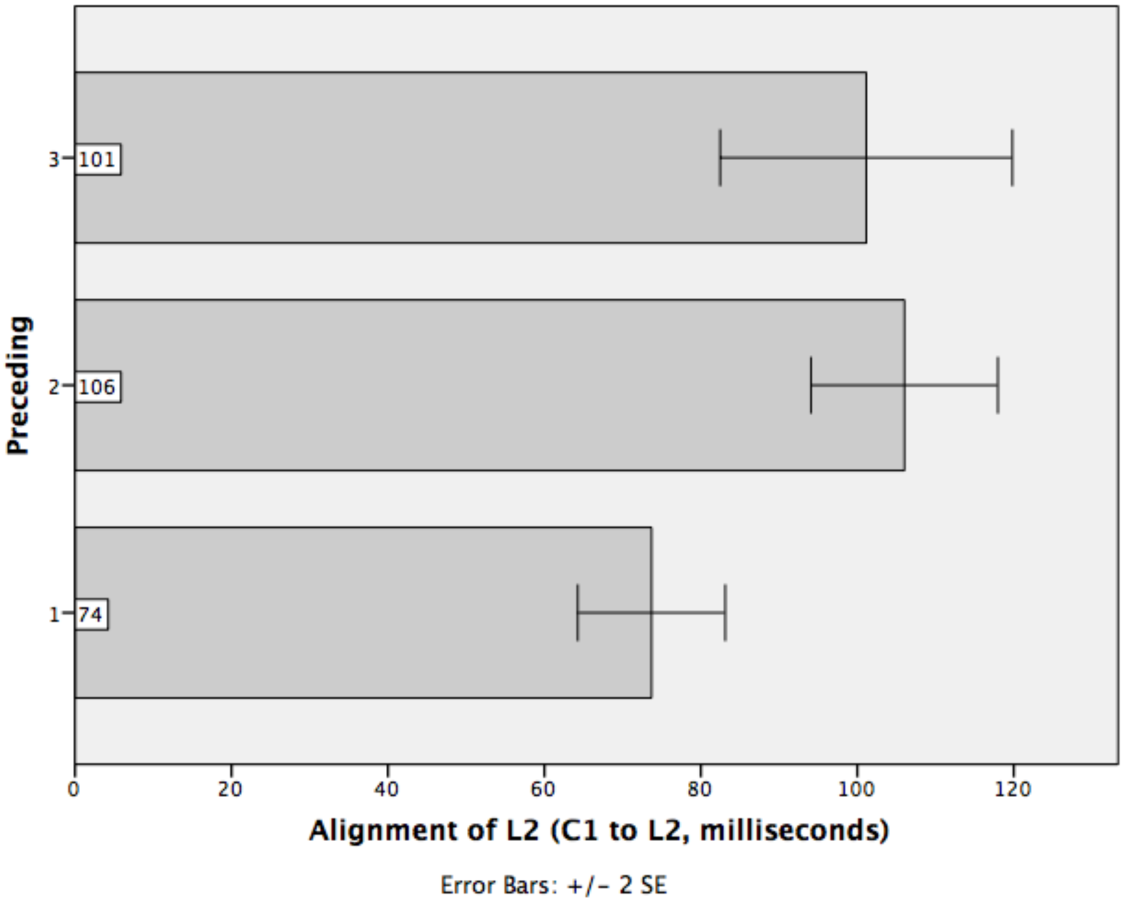


Figure 29: Mean alignment of ***prenuclear L2*** *from onset of accented vowel in ms as a function of* PRECEDING

Thus, for prenuclear L2 there is a two-way effect of tonal clash. With increased proximity to the utterance onset (reduction in the number of PRECEDING syllables) the L2 is realised earlier, while with increased proximity to the nuclear accented syllable (reducing the syllables BETWEEN), the H is pushed earlier. However, the adjustments as a result of the preceding syllables are smaller (~30ms) than the adjustments as a result of between syllables (with a range of nearly 100ms). This particularly variable alignment of prenuclear L2 will be of importance in the consideration of a phonological representation of the tonal targets in Chapter 5.

4.2.2 **Alignment of nuclear targets**

Alignment of nuclear Low 1 (start of rise)

The alignment of **nuclear L1** was only significantly affected by the factor BETWEEN [$F(5, 274) = 2.4$, $p = .037$]. As can be seen in Figure 30, the L1 is far earlier in the 3-between condition, and this is the only significant difference across all post-hoc comparisons [$p = .037$]. In other words, the nuclear L1 when there are 3 syllables preceding the prenuclear accented syllable is on average 10-20ms earlier than when there are 0, 1, 2, 4, or 5 syllables between. However, by and large, the nuclear L1 appears to be aligned just before the consonantal onset of the accented syllable and this alignment is stable across the sentence types (sentence type was not a significant factor in the alignment of L1).

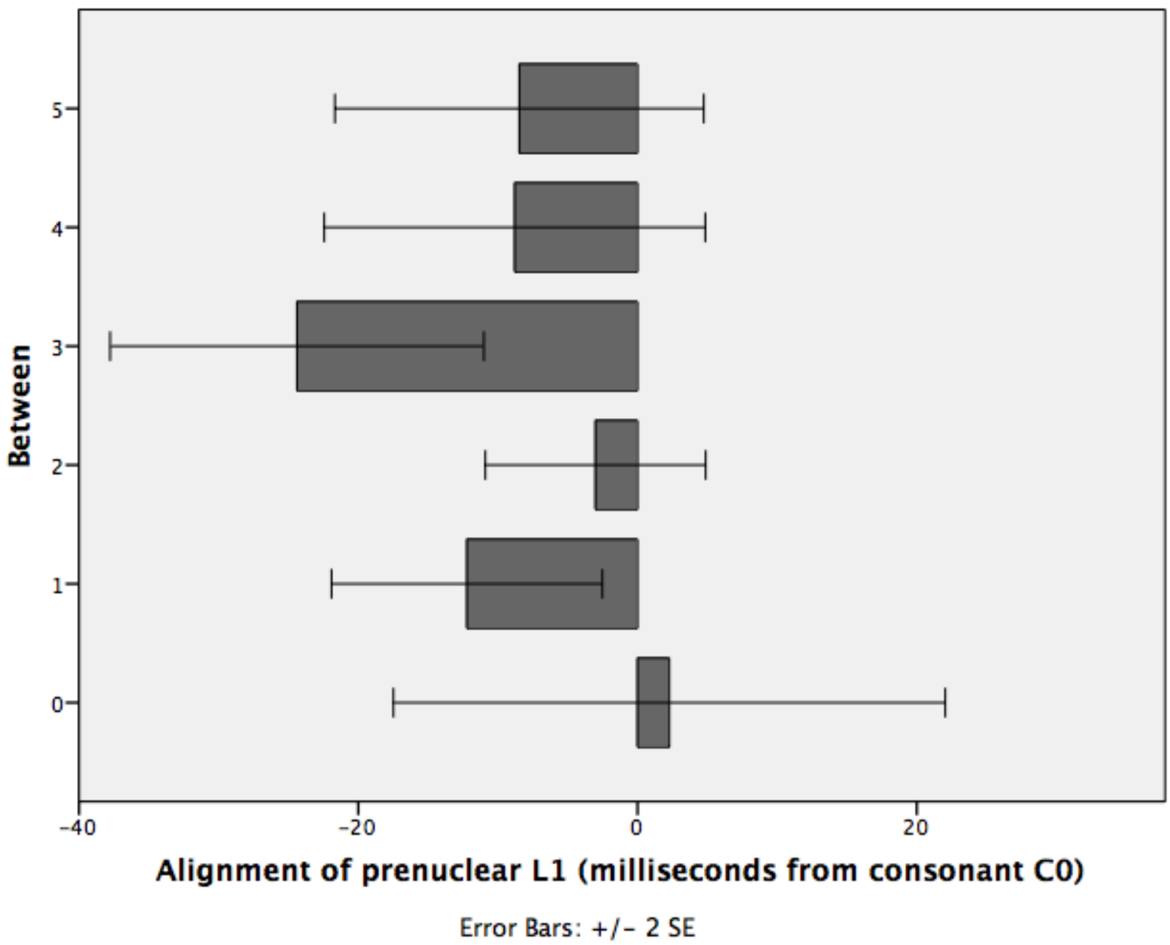


*Figure 30: Mean alignment of **nuclear L1** from onset of accented vowel in ms as a function of* BETWEEN

Alignment of nuclear H

For **nuclear H**, the ANOVA data only showed a significant effect of TAIL for both the C1 to H measure [$F(1, 274) = 36.2$, $p < .001$] and the V to H measure [$F(1, 274) =35.5$, $p < .001$]. The significant effect of TAIL on the alignment of H expressed as a proportion of the vowel was also found to be significant [$F(1, 284) = 39.4$, $p < .001$]. As can be seen from Figure 31 below, when there are 0 syllables following the nuclear accented syllable, the H is aligned significantly earlier than when there is more space available at the utterance end. When there is 0 tail, the nuclear accent peak is aligned just after the onset of the vowel, but when there is a syllable following the nuclear accented syllable (1 tail), the nuclear H aligns around 55% of the way through the duration of the vowel.

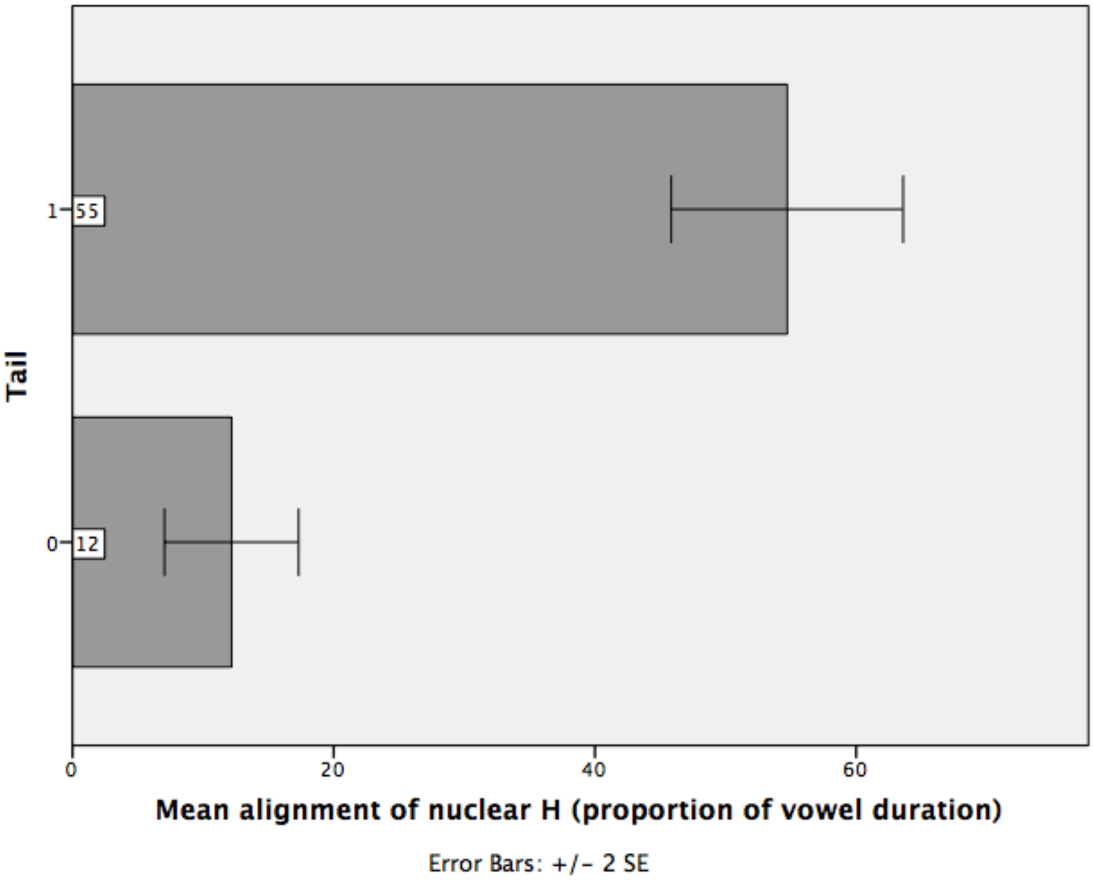


*Figure 31: Mean alignment of **nuclear H** as a proportion of vowel duration as a function of* TAIL

Alignment of nuclear L2 (end of fall)

For **nuclear L2,** only the factor TAIL had a significant effect on the alignment of the target [$F(1, 274) = 76.3$, $p < .001$]. There was no effect of the other variables on the alignment of nuclear L2. As Figure 32 shows, the L2 is aligned far earlier when there is less space following the accented syllable (0 tail). The findings for both nuclear H and L2 replicates previous research for Dutch (Schepman et al, 2006) and Greek (Arvaniti et al., 2006) that upcoming pressure from the utterance end can cause tonal targets to be "pushed" earlier.

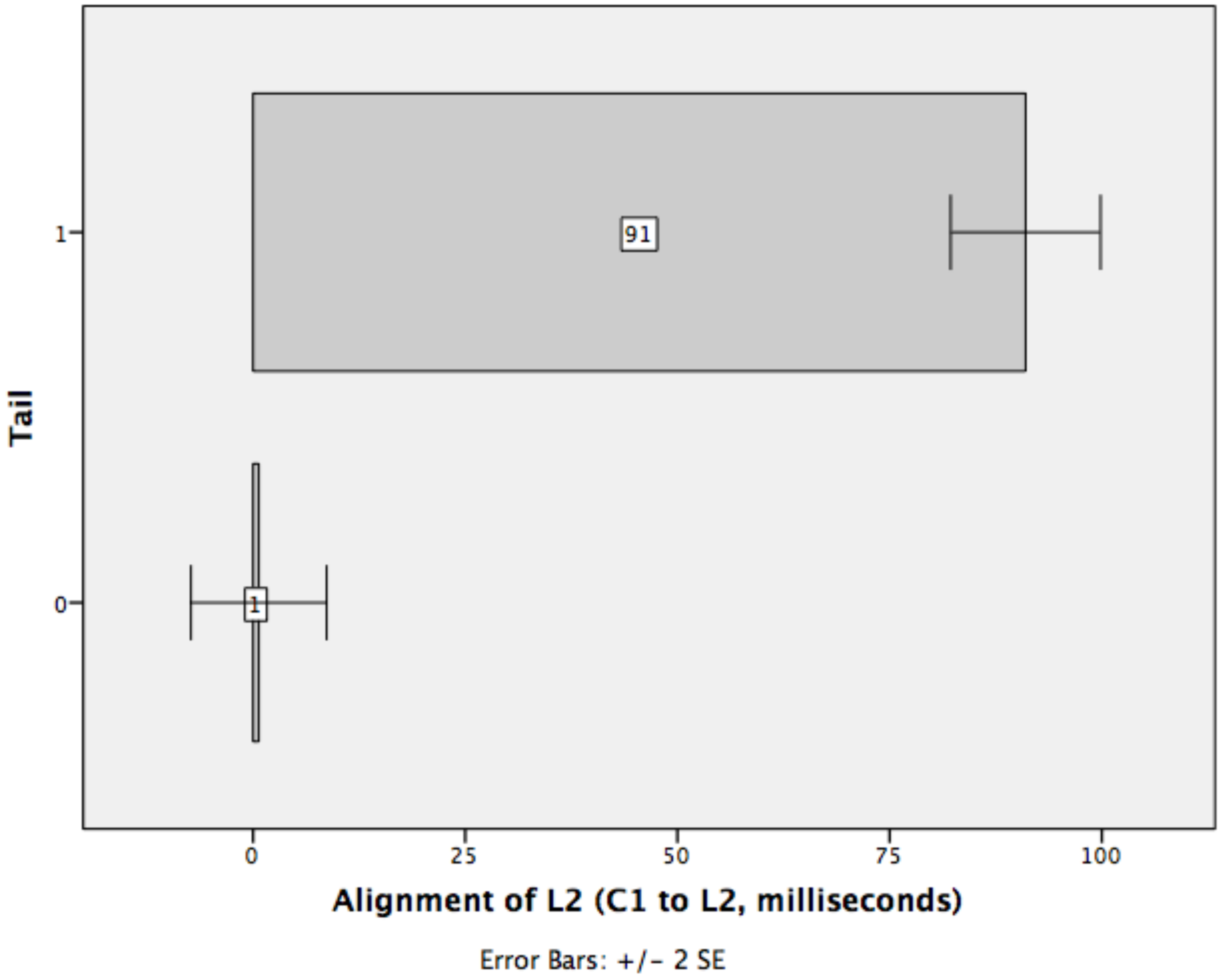


*Figure 32: Mean alignment of **nuclear L2** from offset of accented vowel in ms as a function of* TAIL

Map Task

Figure 33 below compares the mean alignment values for L1 (bottom left panel), H (top panel) and L2 (bottom right panel) across the read and map task data. As can be seen from the data, the alignment of nuclear tonal targets differ somewhat by elicitation method.

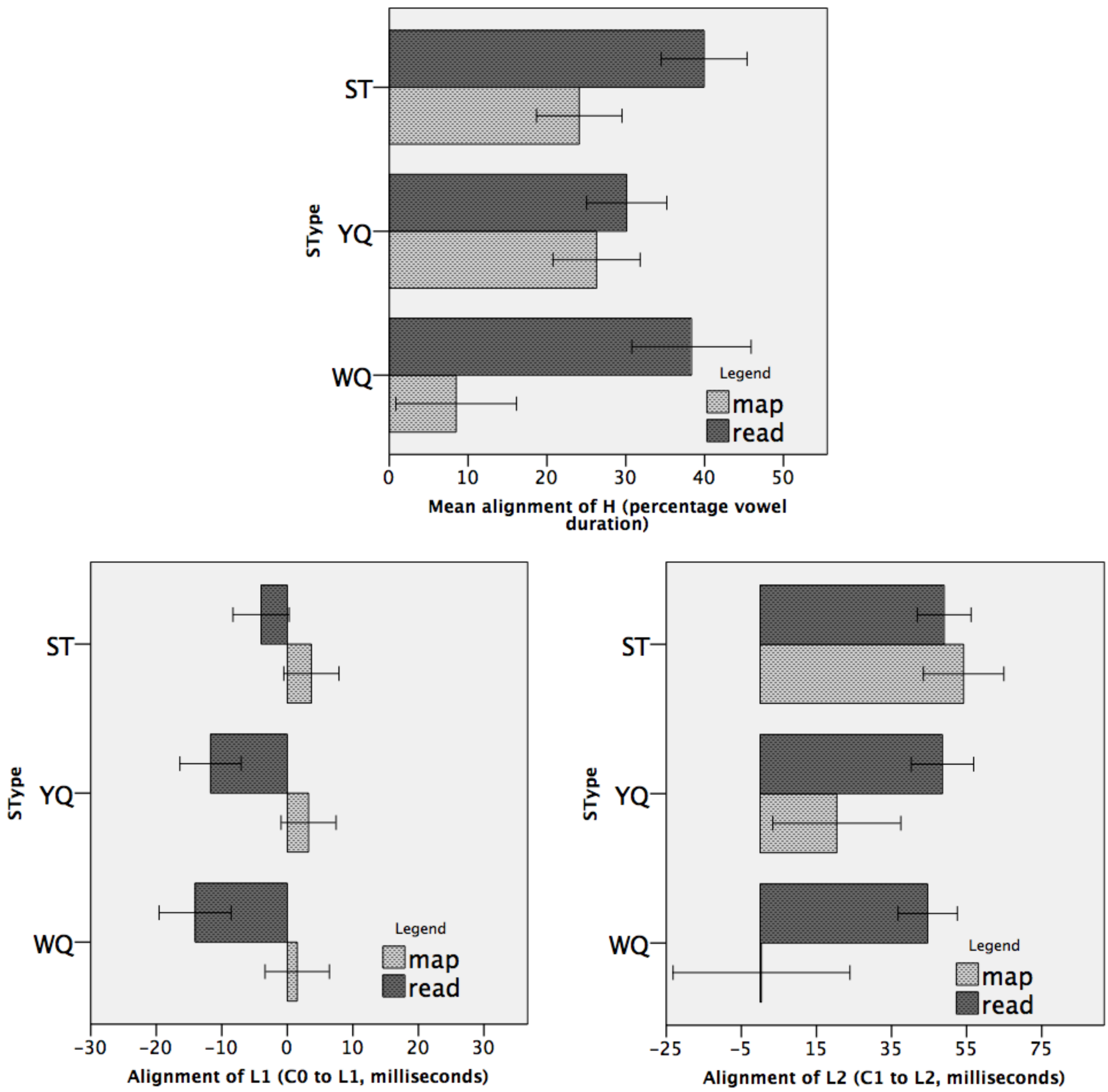


Figure 33: Mean alignment of nuclear L1, H and L2 as a function of SENTENCE TYPE *and elicitation task (reading task vs. map task)*

For nuclear L1 (start of rise), for the measure C0 to L1 (distance from the onset of the accented syllable), in the reading task the L1 was aligned just before the onset of the syllable and in the map task the L1 was aligned just after the onset of the syllable. However, from this figure it is obvious that in all three sentence types there is a tendency for the L1 to align around the onset of the syllable.

With regards to the alignment of the nuclear H target in the reading and map task, the figure above shows that there is overall earlier alignment in the map task as compared with the reading task in all three of the sentence types. However, for the statements and yes-no questions the differences are relatively small. For statements the H occurs 40% of the way through the accented vowel in the reading task and 25% of the way through the accented vowel in the map task. For yes-no questions there is a smaller difference. The H is aligned just over 30% of the way through the accented vowel in the reading task and just over 25% of the way through the accented vowel in the map task. However, in the wh-questions we see a larger difference between the two elicitation methods. In the reading task the H is aligned around 40% of the way through the accented vowel, while in the map task it is aligned just under 10% of the way through the accented vowel on average.

The L2 (end of fall) targets are measured for the distance from the offset of the vowel (C1). The figure above shows that the L2 target was aligned around the same in the statements in both the reading and map task. However, in yes-no questions and wh-questions there is earlier alignment of the L2 target in the map task than in the reading task. There may be a number of reasons for the differences between the reading and map task, which will be further discussed in Section 5.

5 Discussion

In Section 3, it was hypothesized following research on Neapolitan Italian and Russian (D'Imperio, 2000; D'Imperio and House, 1997 and Makarova, 2007) that peaks in Anglesey Welsh may be aligned later in questions than statements. An adaption to Haan's (2002) Functional Hypothesis was made for the Welsh data, which posited that lateness of high tonal targets could vary as a function of the lexico-syntactic marking available to mark interrogativity. There was indeed some evidence for this effect in prenuclear position, with differences in prenuclear peak alignment between the four sentence types. In statements, the H was aligned earliest (around 30% of the way through the accented vowel), followed by wh-questions (44% of the way through the accented vowel), followed by yes-no questions (47% of the way through the accented vowel) and latest in the declarative questions (53% of the way through the accented vowel). A further finding was that both *prenuclear L1 and L2* were also affected by sentence type. The prenuclear L1 was significantly earlier and prenuclear L2 significantly later in WQ than in the other 3 sentence types. A simple explanation for the different alignment in the lows in wh-questions may be to do with the scaling of tonal targets (as presented in Chapter 3). The scaling results showed that of all sentence types, wh-questions have the highest pre-nuclear accent peak in comparison with nuclear targets, which are realised at the bottom of the speakers' pitch range. It is likely that it takes longer to realise this large pitch drop between the prenuclear and nuclear pitch movements, and that this may result in a later alignment compared to other sentence types where the pitch drop is considerably smaller.

It was also hypothesised that there may be later alignment of nuclear accent *peaks* as a function of the lexico-syntactic cues to interrogativity. However, there was no there was no evidence of variable alignment of any of the tonal targets across the different sentence types.

Data from the map task for the three sentence types were compared (ST, WQ, YQ) in order to investigate whether there were different alignment patterns in the semi-spontaneous speech as compared with the controlled speech in the reading task. Across the three sentence types, the L1 (start of rise) targets were very similarly aligned, occurring just before the onset of the accented syllable in the read data and slightly after the onset of the accented syllable in the map task data. A small difference was found in the alignment of the H target in ST and WQ: the H was aligned earlier in the map task as compared with the read data. Finally, the L2 targets were similarly aligned across elicitation methods in the statements but there was earlier alignment in the map task for the yes-no questions and the wh-questions. There may be a number of reasons for these differences. Firstly, it could be due to the fact that the reading data were designed to investigate the effect of the number of preceding and following syllables, and thus were likely to show adjustments to H as a result of these temporal constraints. These effects were not controlled for in the map task data and thus direct comparison between the two without knowing about the proximity of other pitch events or utterance boundaries is problematic. Furthermore, there may have been adjustments in the speaking rate of the speakers in the map task as compared with the controlled reading task. The most probable cause of the variation is the large differences in the number of elicited examples in the reading task compared with the map task. The reading task had elicited 91 ST and 82 WQ while the map task had elicited less than half this number for the statements (44) and only 10 WQ. In further research the control (or modelling) of the temporal constraints, a measure of speaking rate and a larger set of data would perhaps resolve this discrepancy.

It was also hypothesised that temporal constraints may have an effect on the alignment of the tonal targets, such that tonal repulsion may occur when there is less space for a pitch movement to be realised. It was suggested that reducing a) the number of syllables preceding the prenuclear accented syllable, b) the number of syllables following the nuclear accented syllables, and c) the number of syllables between the prenuclear and nuclear accented syllables might cause a shift in the alignment of the tonal targets.

For the prenuclear tonal targets, effects of temporal pressure caused by the systematic variation of the above parameters were indeed observed. However, the prenuclear L1 target tended to be aligned in a fairly stable way, just before the onset of the accented syllable. Prenuclear H was found to be somewhat affected by the proximity of the nuclear accented syllable: there was a general tendency for H to align between 40 and 60% of the way through the accented vowel, but there was significantly earlier alignment in the 1-between condition (and a great amount of variation in the 0 condition). However, the H always occurred *within* the accented vowel in all conditions. For prenuclear L2, on the other hand, the effect of between-syllables was more pronounced. There was a gradient re-alignment of prenuclear L2 as a function of the number of syllables between the prenuclear and nuclear accented syllables. The L2 aligned earlier when there were 0 intervening syllables and was progressively later with more intervening syllables. This variable alignment was quite pronounced, ranging over 100ms and in a clearly gradable way.

For nuclear tonal targets, the L1 appeared to be fairly anchored to the onset of the consonant of the accented syllable, except for the 3-between condition (where L1 was significantly earlier). The H, on the other hand, was subject to alignment adjustments when the number of syllables following the nuclear accented syllables was changed. When there were 0 syllables following (0 tail), then the H aligned earlier in the accented vowel (around 12% of its duration) while in the 1 tail condition it aligned later (around 55% of the way through the accented vowel). However, as with the prenuclear H, these adjustments did not affect the fact that the H was always aligned *within* the accented vowel. There were greater adjustments to the alignment of the nuclear L2 target, which tended to align significantly later in the 1-tail condition than in the 0-tail condition. That is, the nuclear L2 showed a preference to align closely towards the end of the utterance.

The re-adjustments in conditions of decreased 'space' in which to realise the targets replicate previous research described in the second section of this chapter. It was found that all three restrictions on the material available in which to realise the pitch movements (PRECEDING, BETWEEN and TAIL) caused significant re-alignment of tonal targets. For example, as found by Dalton and Ní Chasaide (2005) for Irish and Farrar and Nolan (1999) for English, a rightward drift was present in the alignment of some prenuclear targets when the number of preceding syllables was reduced. Similarly, findings by Silverman and Pierrehumbert (1990) and Prieto (2005) that proximity of prenuclear and nuclear accented syllables can cause significant but gradient re-alignment was found for prenuclear L2 in the Anglesey Welsh data set. Furthermore, the presence of a post-nuclear unstressed syllable was also found to significantly affect the alignment of tonal targets in Anglesey Welsh, confirming findings of previous research (e.g. Schepman et al, 2006, for Dutch; Dalton and Ní Chasaide, 2005, for Inis Oirr Irish; and Arvaniti et al, 2006, for Greek) that tonal targets may be aligned earlier when the utterance boundary is closer.

Additionally, the fact that there were significant re-adjustments to the tonal targets in terms of their alignment (as evidenced by the results presented in Chapter 4) but not in terms of their scaling (as evidenced by the results presented in Chapter 3) suggests that the speakers of Anglesey Welsh resolve situations of tonal clash *not* by adjusting the scaling of tonal targets, but by modifying the timing of the targets with respect to the segmental string. A similar effect has been found by Prieto (2005: 239) for Catalan: “speakers make the effort to reach the F0 target(s)… and do so by using … ‘compression’ and time reorganisation strategies”.

Chapter Five

Intonational phonology

As discussed in Chapter 1, much of the research into intonation is centred on modelling intonation contours using a sparse set of phonological components. However, Ladd (2008b: 373) points out in his review of Jun's (2005) book on prosodic typology, "it is important to distinguish the fundamental theoretical tenets of the overall AM approach to intonation from the specific descriptive claims of Pierrehumbert's analysis of English intonation". The ToBI as well as other "transcription" systems have received criticism due to issues with their approach to and labelling of tone sequences. The first section of this chapter will discuss some of the issues with the transcription methods introduced in Chapter 1, as highlighted in established literature. In light of the issues presented in Section 1, Section 2 will discuss the implications for a phonological analysis of Anglesey Welsh based on the experimental results for the scaling and alignment (rather than by using a pre-defined set of "phonological" labels). This analysis will be related to the previous findings for Welsh in the final section of this chapter.

1 Issues with AM transcription

Transcription methods, and in particular their use of a finite set of labels, have met with considerable criticism in recent literature. One such criticism is outlined by Ladd (1996; 2008a), who points out that there are issues with a lack of phonetic specification in ToBI and Pierrehumbert style analyses. Pierrehumbert (1980) took inspiration for her target-interpolation approach from Bruce's (1977) study of Swedish words accents. Bruce's study provided a linear analysis of pitch contours providing a two-level phonological description expressed in terms of local maxima and minima. That is, the maxima and minima were associated with underlying L and H tones. This concrete realisation of tones as turning points in Bruce (1977) was "one of the important foundations of the AM approach" (Ladd, 2008a: 134). However, Ladd points out that this was abandoned in Pierrehumbert's subsequent analyses: tones need not always correspond to concrete turning points within the contour. The ToBI system, in taking inspiration from

Pierrehumbert (1980) also allows abstract tones to be underlyingly present even if there is no concrete phonetic target in the contour. The reverse is also deemed possible: turning points in a contour need not always reflect underlying abstract tones. As will be shown below, this lack of phonetic specification is argued to be problematic.

An example of a lack of phonetic specification is the treatment of the low turning point between two H* accents in ToBI. Ladd (2008a) highlights issues with the distinction between L+H* and H* pitch accents. H* in Beckman and Hirschberg (1994) is said to be a "peak accent": an apparent target on the accented syllable that is in the upper part of the speaker's pitch range for the phrase. L+H* on the other hand is said to be the "rising peak accent": a high peak target on the accented syllable which is immediately preceded by a relatively sharp rise from a valley in the lowest part of the speaker's pitch range. However, Ladd (2008a: 96) points out that the local pitch peak "might seem to suggest the presence of a leading L before the H* in all cases" (Ladd, 2008a: 96). Furthermore, in a sequence of two H* tones, the L turning point between the two is not taken to reflect an L tone of any sort (ibid. 134). Actually, the L between two H* pitch accents is accounted for by the modelling of H* as a local pitch jump rather than a peak, with a sagging transition between the two accents. However, an H* L+H* is transcribed when the high peak target on the accented syllable is immediately preceded by a sharp rise from a valley in the lowest part of the speaker's pitch range. The proposed distinction between the two is represented in Figure 34 below.

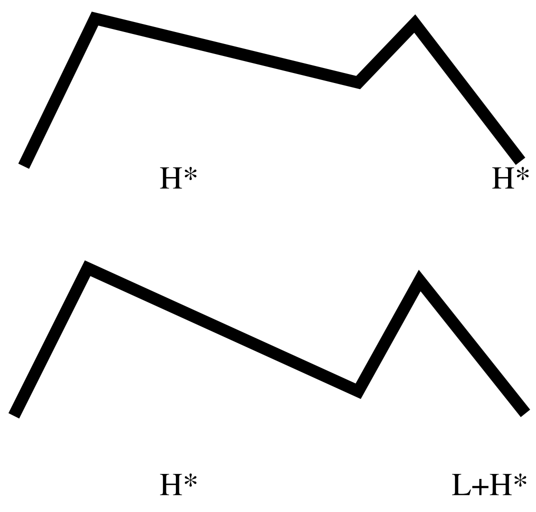


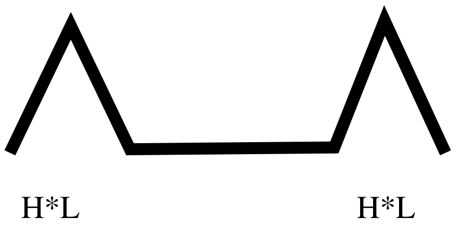
Figure 34: Distinction between L+H and H* following Beckman and Pierrehumbert (1994).*

The concept of the sagging transition between two H* pitch accents departs from Bruce's (1977) straight-line interpolation between tonal targets (Ladd, 2008a: 136). The important issue here is why in one case, the gradual fall and abrupt rise reflect an L tone but in the other there is no reflection of this target in the transcription. This was investigated empirically by Ladd and Schepman (2003), who show that the F0 minimum in supposed H* .. H* sequences of name and surname phrases in English (e.g. the minimal pairs "Norman Elson" and "Norma Nelson") is reliably aligned with the beginning of the accented syllable in production. This thus correlates with the word boundary in the minimal pairs of name + surname. By experimentally manipulating the location of the L target in ambiguous phrases, the listeners' judgements were also more-or less categorical. When the L is aligned with the onset of the /n/, there was a greater proportion of judgements for "Norma Nelson" whereas when the L is aligned with the /e/, there was a greater proportion of judgements for "Norman Elson". Ladd and Schepman (2003: 81) thus argue that the sequence of H*..H* pitch accents actually contains a salient L target which is consistently aligned with the onset of the word. Ladd and Schepman (2003) "do not rule out the possibility that other phonetic differences could provide the basis for Pierrehumbert's original distinction between H* and L+H*… this distinction could be based on differences in pitch range and/or on differences in the alignment of the beginning or end of the rise". However, Ladd and Schepman (2003), in doing instrumental investigations into the realisation of these supposed tonal categories, highlight important issues in ensuring that a distinction provided through a set of labels actually corresponds to a *categorical* difference rather than to fine differences in phonetic realisation.

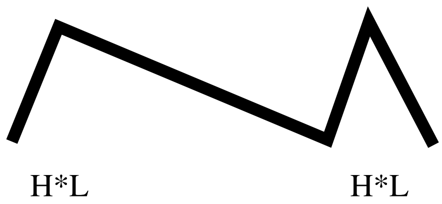
This issue is related to the analysis and transcription of sequences of tones, an issue that is addressed in both ToDI and IViE. Both approaches aim to account for the above problem. Both ToDI and IViE allow only left-headed pitch accents. In IViE, H*L refers to a high target on a prominent syllable followed by a low target on any non-prominent syllables up to the next prominent syllable. H*, by contrast, refers to a high target that is common in initial position in so-called flat hats (as shown in Figure 35 below).

Figure 35: IViE labelling of a flat hat: H* .. H*L

ToDI adopts a similar method, where only concrete phonetic targets are accounted for in the transcription. ToDI reserves the label H* to refer to sustained high pitch in the same way as IViE, while H*L is used to refer to falling pitch. Gussenhoven proposes that there may be various realisations of the tones in a given sequence of accents depending on phrasing and speech rate (Ladd, 2008a: 140). Gussenhoven (2004; 2005) suggests that it is possible to delay or delete tones to link between two pitch accents. Thus, Gussenhoven argues that a sequence of two underlying H*L … H*L pitch accents may have three different variants:



i) Toronto is the capital of Ontario



ii) Toronto is the capital of Ontario

iii) Toronto is the capital of Ontario

Figure 36: Gussenhoven's Tone Linking, adapted from Gussenhoven (2004: 135), Haan, (2002: 31) and Ladd (2008a: 140)

That is, the target of a trailing L of the non-final H*L may be delayed (as in (ii)) where it is timed rightmost and bounded by the following associated tone, or it may be completely deleted. (as in (iii)). In i) we see the basic form, where a low target is found straight after the initial H on *Toronto*. In ii) we see a partial linking, where the trailing tone of the first pitch accent is delayed, is timed rightmost and appears as a leading tone to the following accent (just before *Ontario*). In iii) we see that the trailing tone is deleted completely (referred to as complete linking). Ladd (2008a: 141) points out that by relating the first two contours in the phonology, it suggests that we are dealing with the same thing: the L tone is associated with the first pitch accent but may be moved around. However, it is pointed out that Gussenhoven "loosely exploit(s) various kinds of phonological rules in ways that may not stand up to closer inspection" and in doing so "question(s) the sharp descriptive distinctions drawn by Pierrehumbert" (Ladd, 2008a: 141).

Perhaps the most important issue with the transcription methods is the overall lack of comparability across languages. As we have seen above, ToBI, ToDI and IViE have different methods of analysing and labelling the same contour. The transcription systems were developed for specific languages: ToBI for the description of MAE, ToDI for the labelling of Dutch and IViE for cross-dialectal comparisons of English. However, as Ladd (2008b) points out in his review of Jun's (2005) edited volume *Prosodic Typology: The Phonology and Intonation of Phrasing,* without having a system of successfully capturing typological contrasts across languages, we are unable to draw conclusions about the very nature of prosodic typology. Gussenhoven (2004: xviii) states than "an important advantage of a well worked-out theory is that direct comparisons can be made across languages. Accurate and theoretically responsible descriptions provide the basis for theoretical innovation and improvements in our understanding of the nature of objects we study". However, we do not seem to have arrived at this stage yet. It is not possible for us to make direct comparisons across languages due the fact that there is not yet 'a set of agreed descriptions cast in comparable terms' (Ladd, 2008b: 376).

Furthermore, a number of researchers have raised issues with the use of transcription methods such as those described above to represent phonetic differences in alignment. Atterer and Ladd (2004) point out that "[t]he "star" notation caught on rapidly" and "began to be used in ways that were beyond its original function of indicating the existence of alignment contrasts" (ibid.: 178). That is, the star notation began to be used to refer to alignment differences even when there was no obvious contrast between the two types of alignment.

This is linked to the issues surrounding the process of transcription in general. As discussed in Chapter 1, previous empirical research has focussed on the study of intonation by investigating phonetic differences. These approaches investigate the scaling and alignment of the tonal targets using experimental methods, rather than transcribing the target using a set of labels. Arvaniti et al (2006: 423) state that the alignment of tonal targets can exhibit "complex regularities". The alignment of landmarks in the F0 contour has been found to be predictable, occurring with identifiable points in the segmental string (such as the onset of a stressed syllable) (Atterer and Ladd, 2004: 177). Studies such as Arvaniti, Ladd and Mennen (1998; 2006) for Greek, Grabe (1998) for British English and German; Grabe, Post, Nolan and Farrar (2000) for a number of varieties of British English, Ladd and Schepman (2003) for Southern Standard British English, Ladd, Mennen and Schepman (2000) and Schepman, Lickley and Ladd (2006) for Dutch, and Atterer and Ladd (2004) for two varieties of German have found that pitch accents across languages and across dialects may exhibit variation in phonetic realisation and that these differences may have implications for the phonological analysis. Many of these studies explicitly object to the use of transcription systems such as ToBI without prior and rigorous testing of the existence of an underlying phonological contrast. Beckman et al. (2005) point out that the original ToBI system and the set of phonological labels for MAE were based on a large body of research which had established the intonational events and tonal contrasts that exist. However, the ToBI system is very often applied to other varieties, or other language varieties without taking into account such previous research, simply using an arbitrary set of labels in order to account for variation (which may or may not be categorical or phonologically important). Arvaniti et al (2006: 424) suggest that focussing on creating "phonological representations of tones simply in order to reflect phonetic detail…" is inappropriate and "as in all other areas of phonology, phonological distinctions should be established on the basis of meaning and contrast and after taking into consideration the entire system under examination".

Thus, this thesis has not adopted a transcription method for Anglesey Welsh. It is argued that without a thorough understanding of what exists at the fine-grained phonetic level, a phonological analysis should not (and cannot) be established (after Arvaniti et al., 2006). The findings presented in Chapters 3 and 4 on the scaling and alignment of the tonal targets in the F0 contour provide a great deal of information which can be used to inform a discussion of the phonological structure of tones in Anglesey Welsh.

2 The autosegmental representation of Anglesey Welsh intonation

Following AM tradition in the analysis of intonation, it is assumed here that H and L tones may be separated into pitch accents or edge tones. A pitch accent is generally described as a pitch movement at a prominent syllable (Arvaniti et al. 2006: 668), while edge tones are associated with the segments at a relevant phrase boundary (Beckman et al. 2005: 15).

The structural organisation of the grouped tones in a pitch accent is contested in AM literature, as we saw with the different transcription guidelines in ToBI, ToDI and IViE. In general, the star notation (T*) is used to denote the synchronisation and association of a tone with the accented syllable, "occurring within the same time slot" (Grice, 1995: 183). Unstarred leading and trailing tones may also be associated but occur at a "stipulated distance" before or after the starred tone (ibid., 183). However, in bitonal pitch accents, the question of whether the first or the second of two pitch accent tones is starred, and therefore associated, is a phonological choice (ibid.: 183). This headedness is one of the most contested principles in AM theory. We have seen, for example, that Pierrehumbert (1980) uses pitch accents that contain a starred tone and an optional unstarred tone "either to the left, referred to as a leading tone, or to the right, referred to as a trailing tone" (Grice, 1995: 183). In this analysis, the star notation is used to indicate a strength relation, with the starred tone aligning and associating with the metrically strong syllable, and unstarred tones occurring "off the syllable" (Pierrehumbert, 1980: 239). This left- or right-headed analysis has continued in further models (e.g. Pierrehumbert and Beckman, 1986 and the ToBI guidelines Beckman & Ayers Elam, 1997). However, we also saw that in bitonal pitch accents in IViE and ToDI that the leftmost tone of a pitch accent is automatically associated with the accented syllable and the second tone is always the trailing tone. As a result, the pitch before the accented syllable (the preaccentual pitch) can "only be accounted for either by a tone belonging to a previous accent or an initial boundary tone" (Grice, 1995: 188). Gussenhoven's tone linking is an example of this, where the tone of a previous left-headed pitch accent may shift from the original post-accentual position to the preaccentual position of the next pitch accent (see Chapter 1 for further explanation).

The next section will investigate the relationship between the tonal targets found in the corpus of Anglesey Welsh, and will propose how they are best analysed in terms of their structural organisation.

2.1 The starred tone

The alignment results for Anglesey Welsh show that both the prenuclear and nuclear L1 and H targets are aligned in a stable way to segmental landmarks. The *H target* is very consistently aligned and always occurs *within* the accented syllable, specifically within the accented vowel. Although there was some evidence of slight adjustments in conditions of tonal clash, the alignment of H is fairly stable in both prenuclear and nuclear position (occurring on average between 17 and 30% of the way through the accented vowel for both).

There is also evidence for fairly stable alignment of the *L1 targets*. In prenuclear position, in ST, YQ and DQ, the L1 target is associated with the onset of the accented syllable, occurring at or just before its onset. There was an exception to this in the WQ where the L1 target occurred around 38ms before the onset of the accented syllable. However, as with the other three sentence types, this L1 target was found to be stable and not affected by the proximity of upcoming targets or the preceding utterance boundary. This suggests that in all four sentence types that the L1 target in prenuclear position is anchored in a fairly stable way, in ST, YQ and DQ around the onset of the syllable and in WQ 38ms before the onset of the accented syllable. The same type of stability is found in nuclear position. The L1 is associated in a fairly stable manner with the onset of the accented syllable (occurring on average between 5 and 10ms prior to the onset of the consonantal onset of the accented syllable), and this holds true for all sentence types.

With regards to the organisation of tones into pitch accents, it is generally accepted that “the starred tone… is aligned with the accented syllable” (Ladd, 2008a: 96). Thus, while both the L and the H targets are associated with the accented syllable, it is clear that the H target is more strongly associated given its alignment *within* the accented syllable. The fixed location of the L1 target just *outside* the accented syllable suggests that it could be considered as a stable leading tone that is associated close to the accented syllable, or – in Pierrehumbert (1980) terms – occurring just "off the syllable" (Pierrehumbert, 1980: 239). Furthermore, the fact that neither the scaling nor alignment of the L1 target are systematically affected by the number of intervening syllables, further confirms its analysis as a stable leading tone which is associated with the H*. Taken together, this suggests that this particular pitch accent which is present in both prenuclear and nuclear position is best analysed as L+H*.

2.2 'Prenuclear L2'

With regards to what was referred to as the 'prenuclear L2 target' (end of fall), its phonological analysis is less straightforward. There are significant adjustments to the alignment of the prenuclear L2 as a function of the number of syllables between the prenuclear and nuclear accented syllables. That is, there is gradient earlier alignment with fewer intervening syllables. This context-dependent variation is reported as behaviour exhibited by unstarred tones (Pierrehumbert and Steele, 1989; Arvaniti, Ladd and Mennen, 2000). However, we have already seen that an unstarred L tone has been proposed in the analysis of the nuclear pitch accent as L+H*. Due to the fact that the 'prenuclear L2' is variable as a function of the number of intervening syllables between the prenuclear and nuclear accented syllable, it could be suggested that this is evidence of tone spreading. That is, the 'prenuclear' L2 target could in fact be a reflex of the leading L tone from the *nuclear* L+H* spreading leftwards as far as is possible in conditions of tonal clash. Liberman (1975) proposed that a tone might spread onto intervening syllables between accented syllables. In his English example as shown in Figure 37 below, the L tone associated with the accented syllable in '*eSPEcially*' primarily spreads rightwards onto the "free" unaccented syllables between that and the following accented syllable in '*preCAUtions*':

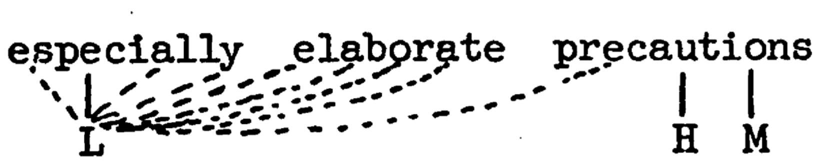


Figure 37 Liberman's (1975: 102) tone spreading in left-to right direction

Liberman states that "the fact that the intervening free syllables take on the preceding low tone, rather than the following high tone, tells us that English prefers to spread tones left-to-right rather than right-to-left (really, <u>forward</u> in time rather than <u>backward</u>)" (Liberman, 1975: 102, emphasis in original).

This spreading is noted as a characteristic of unstarred tones (Pierrehumbert, 1980; Grice et al. 2000). The results for Anglesey Welsh show that the 'prenuclear L2' systematically varies as a function of the number of syllables between the prenuclear and nuclear accented syllables in Anglesey Welsh, and that the low stretch between prenuclear L2 and nuclear L1 is variable in length as a function of the number of intervening syllables. This suggests that Anglesey Welsh prefers to spread tones backward in time rather than forward in time. Liberman's tone spreading could be a feasible explanation for the variability in the "prenuclear" L2 target. In Figure 38 below the proposed tone-spreading from right-to-left is represented diagrammatically.

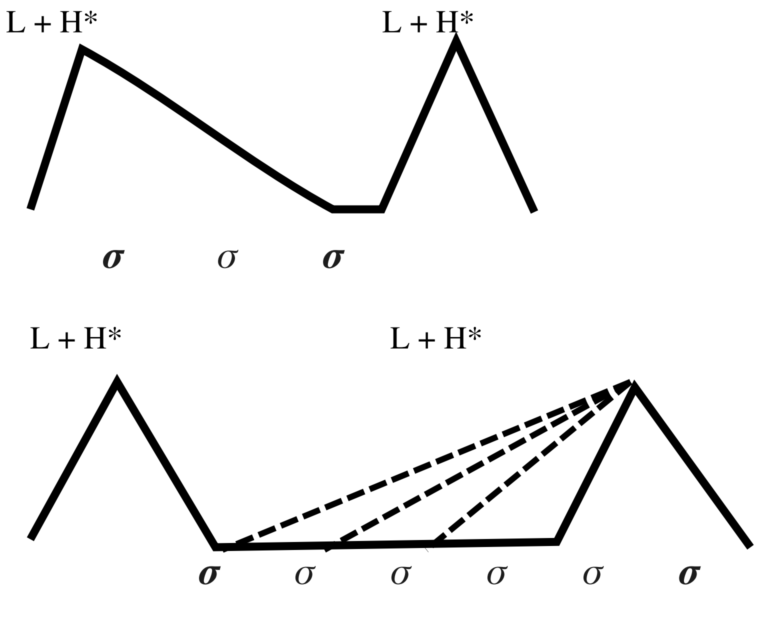


Figure 38: Proposed tone spreading of nuclear L+H with increasing intervening unaccented syllables*

It could be argued that the leading L tone in the nuclear L+H* pitch accent has a primary association with the onset of the accented syllable but may have a secondary association with an earlier part of the utterance. As the labelling method used in this thesis labelled only the offset of the accented vowel, it is not possible to establish the exact point or landmark of this secondary association. However, given the scaling similarities but gradient variation in alignment, it suggests that 'prenuclear L2' is a target that is subject to realignment. It is left as a matter for future research to determine whether the 'prenuclear L2' has a secondary association and, if so, with which particular landmarks in the segmental string it associates.

2.3 Boundary tone or phrasal accent?

In all four sentence types, there was a fall in F0 after the nuclear accent peak towards the nuclear L2 (end of fall). Instrumental results for nuclear L2 showed that it is not undershot or re-scaled in conditions of clash with the utterance end. Where there is a 1-syllable tail, the F0 falls to the same level as when there is no tail (i.e. there was no significant difference in the scaling across the 0 tail and 1 tail conditions). However, there were significant adjustments to its alignment. When there is a 1-syllable tail, the target aligns significantly later than when there is no tail present.

The evidence that there is no apparent undershoot but there is earlier alignment when there is no tail, suggests that this is a salient L tone that seeks to align with the utterance edge. When there is 0 tail, the L2 aligns with the end of the accented syllable (1ms after the offset of the accented vowel) but when there is 1 tail the L2 aligns into the following syllable (90ms after the offset of the accented vowel). In the data collected for Anglesey Welsh the end of the utterance also coincides with the end of the intonational phrase. That is, the salient L point "occur[s] at the very edge of the constituent" (Grice et al. 2000: 144) suggesting that this could be a low boundary tone L% that seeks to associate with the end of the prosodic domain.

An alternative interpretation is that this L tone may be an L phrase accent which, when further post-accentual syllables are available, spreads and thus creates a stretch of low F0. Grice et al. (2000) explain that phrase accents are boundary tones that can have two types of association, a primary association to the phrasal boundary and a secondary association to another unit in the post-nuclear syllables. It could be argued that the L target that we find in Anglesey Welsh is the co-occurrence of an L phrase accent and an L boundary. If this alternative explanation were correct, we would expect to find a stretch of low F0 between the end of the fall and the phrasal boundary, which would be longer the more unaccented syllables were added. It was not possible to test this in our data set for Anglesey Welsh as the number of post-accentual syllables was only varied between 0 and 1.

However, data from the pilot experiment may be able to shed further light on this issue. The findings of the pilot experiment showed that when further lexical items were added to the end of an utterance (e.g. ar ôl 'remaining', eto 'yet, again', ddoe 'yesterday', o'r blaen 'before', rwan 'now'), they appeared to attract an additional accent (as can be seen in Figure 39 and *Figure 40* below):

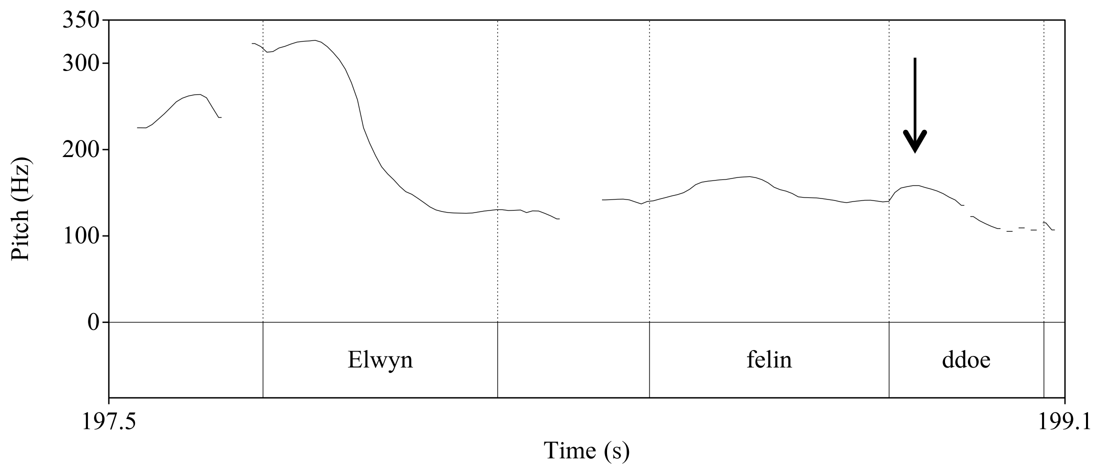


Figure 39: Pitch trace of 'Wnaeth <u>El</u>wyn fynd i'r <u>fe</u>lin <u>ddoe</u>?' 'Did <u>El</u>wyn go to the <u>mill</u> <u>yesterday</u>?'

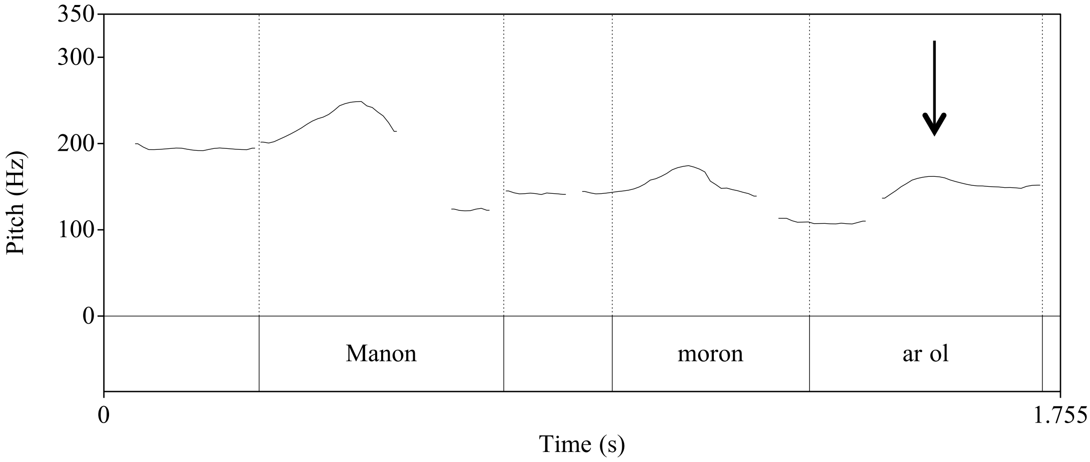


Figure 40: Pitch trace of 'Mae gan Manon un moron ar ôl.' 'Manon has a carrot remaining'

As can be seen in Figure 39 and *Figure 40*, there is a further accent on the added lexical items *ddoe* and *ar ôl*. This suggests that at least this speaker does *not* have a flat low F0 that stretches from the end of the fall until the end of the utterance. On the basis of this speaker's data it appears that the nuclear L2 target should be analyzed as a boundary tone rather than a phrase tone. However, further research would be required in order to test whether these findings hold for more than this one speaker.

The fact that this final low occurs in all four sentence types is an interesting finding. It was noted in Chapter 3 that one of the many indicators of interrogativity cross-linguistically is a final rise. In fact, Hirst and Di Cristo (1998: 25) conclude that "by far the most common characteristic … is a final high pitch" in non-emphatic yes-no questions in their survey of the intonation system of twenty languages. However, final high pitch was not found to be present in the questions gathered for Anglesey Welsh. Instead, the yes-no and declarative questions clearly featured a rising - falling movement in nuclear position. While Hirst and Di Cristo (1998) suggest that final high pitch in yes-no questions is common, it has been found that a number of languages do not feature final rising pitch (e.g. Hungarian, as discussed by Ladd, 2008: 82; Bengali, as discussed by Gussenhoven, 2004: 54; and Greek, as discussed by Arvaniti et al, 2006). It appears that yes-no and declarative questions follow this pattern of final falling pitch in Anglesey Welsh.

2.4 **Wh-words**

As touched upon in Chapter 3, the wh-questions contained a wh-word, which may potentially have attracted an additional pitch accent. In the design of the stimuli, the aim was to elicit a pitch accent on two of the content words in the four sentence types. However, it has been reported in previous literature that wh-words may feature a high pitch utterance initially. For example, Watkins (1961) predicts for Welsh that the wh-word features the highest pitch in the utterance:

b) ^{1}Pwy ^{2}torrodd ^{3}y ffenestr.
Who break.3S.PAST the window
'Who broke the window?'

One might argue that Watkins was referring to a pitch accent on the wh-word. However, it was not possible to test this in the data collected for this thesis, because most of the wh-words in Welsh (*pwy* 'who' [puɨ], *be* 'what' [be], *lle* 'where' [ɬe], *sut* 'how' [sɨt], *pam* 'why' [pam], *pryd* 'when' [pr̥ɨd]) are short monosyllables that contain voiceless plosives or fricatives word-initially, and therefore reliable measurement of F0 was not possible on the wh-words. However, it should be pointed out that in wh-questions the low leading tone of the prenuclear pitch accent (L+H*) actually occurs significantly earlier than in the other three sentence types. It could thus be argued that due to the early occurrence of this tone, there is not enough 'space' available to realise a full pitch movement on the wh-word. Furthermore, during the data analysis, there was no auditory prominence on wh-words in the broad focus examples used, suggesting that there is no additional pitch accent on this wh-word.

2.5 **Previous findings for Welsh**

A number of studies were reported in Chapter 2 that have considered the primary pitch movements in nuclear position for a number of varieties: Thomas (1967) for Natgarw Welsh, Pilch (1975) for Aberystwyth Welsh, Rees (1977) and Rhys (1984) for a South-East Dyfed variety and Evans (1997) for a Cardiff variety.

Early work by Watkins (1961) for Welsh used a simple numerical system to transcribe the pitch patterns in different sentences. Watkins transcribed the pitch patterns in wh-questions and statements as a 1-2-3 pattern (with 1 being high and 3 being low):

c) ^{1}Welodd ^{2}John ^{3}y bachgen.
see.3S.PAST John the boy
'John saw the boy.'

d) ^{1}Pwy ^{2}torrodd ^{3}y ffenestr.
Who break.3S.PAST the window
'Who broke the window?'

For yes-no questions Watkins (1961) observes a rising pattern:

e) ^{3}Welodd ^{2}John ^{1}y bachgen?
see.3S.PAST John the boy
'Did John see the boy?'

These findings are corroborated by the data for Anglesey Welsh. In statements and wh-questions the prenuclear pitch movement is realised at a higher level than the nuclear pitch movement. There appears to be a downward trend present in these two questions while in the yes-no and declarative questions, the nuclear pitch accent is realised at a higher level than the prenuclear pitch accent, and an upward trend is visible. This is exemplified in Figure 41 below.

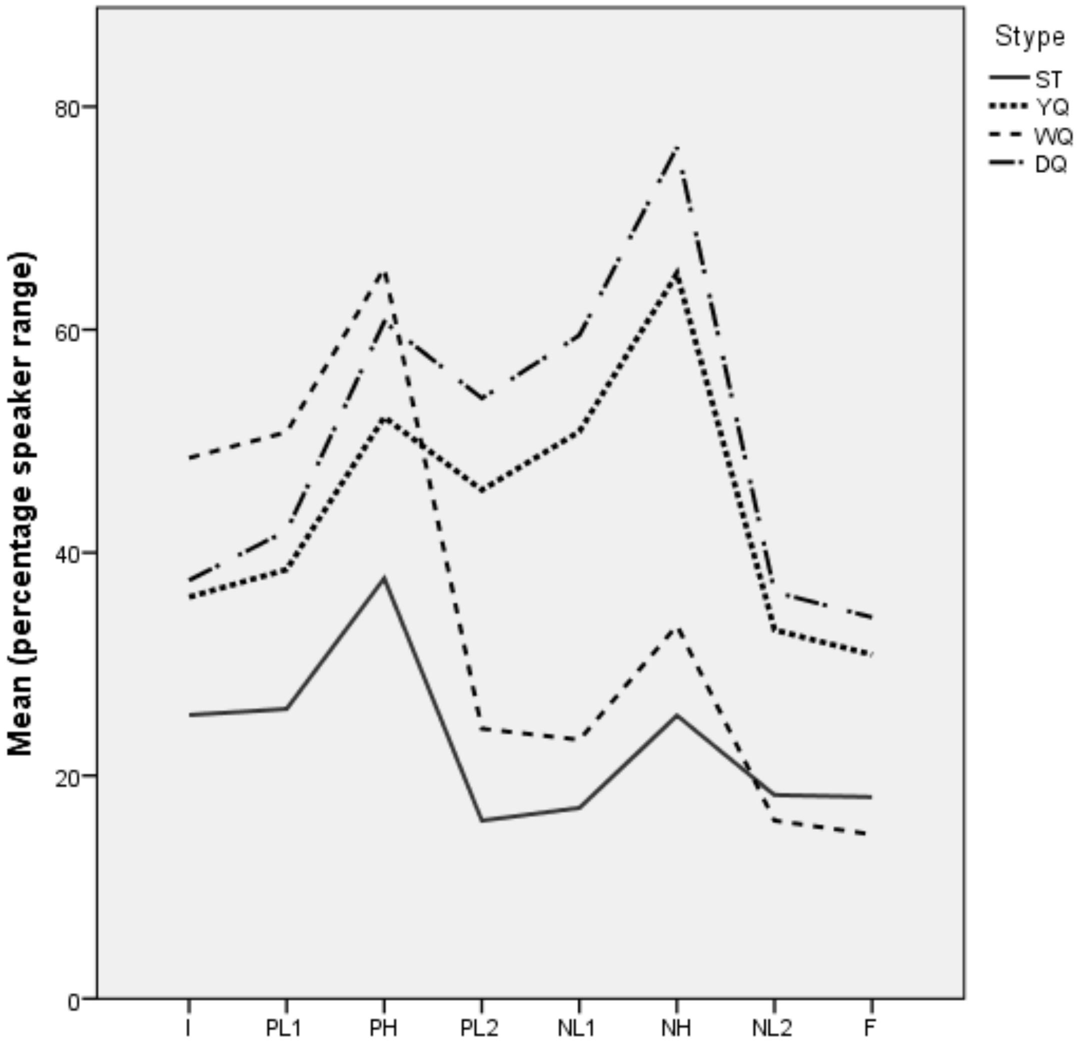


Figure 41: Contour shape (%) as a function of SENTENCE TYPE *for the reading task for the labelled points I (initial) prenuclear low 1, prenuclear high and prenuclear low 2 (PL1, PH, PL2), nuclear low 1, nuclear high and nuclear low 2 (NL1, NH, NL2) and utterance offset (F).*

These two patterns have been confirmed for the Anglesey Welsh data with statements and wh-questions featuring an overall falling pattern, while yes-no questions and declarative questions feature a rising pattern.

Further work by Thomas (1967) Pilch (1975), Rees (1977) and Rhys (1984) and Evans (1997) suggested that there is a large inventory of possible of nuclear pitch accents (e.g. fall, rise, rise-fall, level). It is however noted by Evans (1997) that the main pattern found in declarative statements (in Cardiff Welsh) is a low pitched accented syllable, followed by a rise and subsequent fall which she represents as L* H- L%. Conversely, results from this thesis show that the main nuclear pattern found across all sentence types in Anglesey Welsh is L+H* L%.

There may be a number of reasons for the differences between the previous studies and the findings for Anglesey Welsh. One explanation is that this is due to regional variation, which influences the realisation of pitch accents in Welsh. As pointed out in Chapter 2, previous research on Welsh intonation has concentrated on varieties that are geographically distant from the Anglesey Welsh variety investigated in this thesis. The closest study is that of Pilch (1975) who based his analyses on an informant from Aberystwyth, which is 85 miles from Anglesey. While Hannahs (2013) broadly distinguished Welsh into northern and southern dialects, in fact there is a great amount of variation in the Welsh spoken in the midlands, as evidenced by the lexical and syntactic variation reported in Thomas and Thomas (1989), Borsley, Tallerman and Willis (2007) and Thomas (2000).

Researchers have shown an increasing interest in cross-varietal differences in the realization of intonation. For example, Atterer and Ladd (2004) found that Southern German speakers align prenuclear rises later than Northern German speakers. Dalton and Ní Chasaide (2005) also report that tonal alignment is different across different dialects of Irish. They compared two dialects of Irish: one in the North (Gaoth Dobhair) in Ulster, and one further south (Cois Fharraige) in Connaught. They found that in both prenuclear and nuclear position the peaks are aligned later in the north. Although they transcribe this (using IViE) as L*+H for the northern variety and H* for the southern variety, they also question whether such apparently dissimilar patterns might be regarded as different phonetic realizations of the same underlying pattern (i.e. differing in terms of the alignment to the accented syllable nucleus). Arvaniti and Garding (2007) found similar alignment differences between varieties of American English, where Southern Californian speakers align peaks earlier than Minnesotan English speakers. Dialectal variation may indeed be an explanation for the difference found between the Anglesey Welsh findings of an high star associated with the accented syllable in the present thesis and Evans' (1997) findings of a L* in Cardiff Welsh.

However, differences between previous research and the present study may also have arisen due to the methods used for the observation or analysis of the data. Most of the previous research on Welsh suprasegmentals is based on observational data or the method is not well described. While we know the location of the speakers or varieties described by Thomas (1967), Pilch (1975) and Rhys (1985), the age of the speakers or elicitation methods used (if any) are not reported. As a result, we are not able to deduce whether any differences between the present study and those previously undertaken are because of dialect-related differences, age-related differences or simply a result of the methods used.

Related to this point, Williams (1985; 1989) reports that lexical stress in Welsh may not be evidenced by increased pitch on the traditionally "stressed" vowel in the penultimate syllable. She suggests that stress may be separate from prominence and that the unstressed ultima may feature a pitch peak. Evans (1997: 35) also suggests that a reason for the presence of a high phrase accent after an L* in her analysis of Cardiff Welsh reflects "the fact that in Welsh the unstressed syllables have a tendency to rise following the stressed syllable". However, the data for Anglesey Welsh show that the stressed syllable features a pitch peak and that the F0 falls onto the following syllable (if present). Thus, it appears that, at least in connected speech in Anglesey Welsh, intonational accent and stress co-occur on the penultimate syllable. This could indeed be indicative of variation in the realisation of stress across dialects, but it may also be due to issues with Williams' methodology and the observational nature of previous research by Jones (1949), Watkins (1961), Thomas (1967), Oftedal (1969) and Bosch (1996). During data collection, measurement and analysis for this thesis, there has been no evidence of any perceptual or measurable prominence on the ultima in polysyllabic words. While this study did not specifically investigate the acoustic correlates of stress in Welsh, it has found that intonational peaks are aligned consistently with the penultimate stressed syllable and suggests that the reported features for stress 'in Welsh' (Williams, 1989) may not actually hold for this variety (or other varieties for that matter).

Chapter Six

Summary and conclusions

The main aim of this thesis was to provide an analysis of the Anglesey Welsh intonation system using the autosegmental-metrical framework. Previous research on Welsh intonation in general has mainly used different non-instrumental methods and prior to this thesis, no systematic study of Anglesey Welsh intonation had been undertaken. Specifically this thesis investigated the phonetic realisation of tonal targets in Anglesey Welsh by investigating their scaling (Chapter 3) and their alignment (Chapter 4). Within these chapters, the phonetic realisation of intonational targets in statements was compared with those of three questions (yes-no questions, declarative questions and wh-questions) in order to test the realisation of interrogativity in this variety. Furthermore, the study investigated the effect of reducing the syllabic material available in which to realise the intonational targets. This was done in order to investigate whether adjustments were made to the realisation of tonal targets under conditions of increased temporal pressure. This quantitative phonetic investigation of the scaling and alignment of intonational targets was used to inform a discussion (Chapter 5) about underlying phonological structures present in the variety.

To achieve these aims, four male and two female speakers of Anglesey Welsh provided an experimental corpus of read speech for the four sentence types as well as a smaller semi-spontaneous map task corpus, which was used for comparison of the scaling and alignment data. Given the exploratory aims of this research, the hypotheses and research questions were based on previous research about the phonetic implementation of intonational targets in languages other than Welsh. These hypotheses were tested with the Anglesey Welsh data set and the data were found to show some similarities as well as differences with other languages.

The present chapter will begin by presenting the main observations and findings. Further observations and implications arising from this research are considered in Section 2. In Section 3 suggestions are made for further research in the area of Welsh suprasegmentals.

1 Main observations and findings

1.1 Scaling

The scaling study (presented in Chapter 3) investigated the manipulation of two factors: sentence type and temporal constraints. The following research questions were addressed:

- Do the four sentence types (statement, yes-no question, wh-question, declarative question) differ in the height of valleys and peaks?
    - And are these points scaled higher in questions than in statements, and is this scaling gradable as a function of lexico-syntactic marking?
- Does decreased "space" affect the height of highs and lows (by reducing a) the number of syllables PRECEDING the prenuclear accent, b) the space BETWEEN prenuclear and nuclear accented syllables and c) the number of post-nuclear syllables (TAIL)?

The first research question was formulated on the basis of previous research, which found that there may be differences in the scaling of tonal targets across sentence types (Haan, 2002; Makarova, 2007; Grabe, 2004) and that these scaling differences may be gradient as a function of the lexico-syntactic marking available to indicate interrogativity (Haan, 2002). The data in the present thesis show that nuclear tonal targets (L1, H and L2) in declarative questions (which are the least lexico-syntactically marked question in Welsh) were highest, followed by yes-no questions (which may be lexico-syntactically marked by a different form of the verb *to be*), followed by the lexically marked wh-questions. The lowest L1, H and L2 targets were found in statements. For the prenuclear targets, all three question types (yes-no questions, wh-questions and declarative questions) were realised significantly higher than the statements. However, the order did not follow the order predicted by Haan's (2002) functional hypothesis: wh-questions featured the highest L1 and H targets and DQ and YQ were realised just below this. Nevertheless, this result shows that there is an overall higher pitch in questions as compared with statements.

The second research question was related to temporal constraints and whether decreased space would result in a re-scaling or undershooting of the high and low targets. No evidence was found of re-scaling in conditions of tonal clash, suggesting that the F0 targets for speakers of Anglesey Welsh are not truncated or undershot, as had been found for other languages. This is similar to findings for Catalan by Prieto (2005) who found that pitch peaks in both prenuclear and nuclear position were consistently as high or low in conditions of tonal clash as in conditions with reduced tonal clash (although Prieto did find adjustments in the alignment of tonal targets).

1.2 **Alignment**

The alignment study was the focus of Chapter 4. The same two factors investigated with regards to scaling described above (sentence type and temporal constraints) were applied to the alignment data, and the following research questions were addressed:

- Do the four sentence types differ in the alignment of the tonal targets (L1, H and L2) in nuclear and prenuclear position?
    - Are tonal targets (H and L) aligned later in questions than in statements, and is this alignment gradable as a function of lexico-syntactic marking?
- Does decreased "space" affect the alignment of highs and lows (PRECEDING: 1, 2, 3; TAIL: 0, 1; BETWEEN; 0, 1, 2, 3, 4, 5)?

The first research question investigated the effect of grammatical function on the alignment of tonal targets based on previous research that had found that interrogativity might be cued by delayed tonal targets (D'Imperio, 2000; Makarova, 2007). Furthermore, the sub-question applied Haan's (2002) Functional Hypothesis to alignment, testing whether delayed tonal targets would be gradable as a function of the lexico-syntactic cues for interrogativity. While SENTENCE TYPE was found to be a significant factor affecting the alignment of the prenuclear targets, the post-hoc tests indicated that for L1 (start of rise) and L2 (end of fall), there was significantly different alignment in the wh-questions than the other three sentence types. The L1 target was aligned significantly earlier and the L2 target significantly later in wh-questions. However, at the L2 point, the F0 of the WQ drops dramatically to below the height of the other two question types (prior to this point it is realised highest), and thus the time taken for this large fall may take longer for a speaker to realise. Furthermore, SENTENCE TYPE had a significant effect on the alignment of the *prenuclear* H target and there was a tendency for peaks to align later as a function of the lexico-syntactic markers for interrogativity. However, the differences were small and regardless of these adjustments the H targets were always realised *within* the prenuclear accented syllable.

With regards to the nuclear tonal targets, there was no significant effect of sentence type on the scaling of L1, H or L2, suggesting peak delay is not a feature implemented in the encoding of interrogativity in Anglesey Welsh for nuclear targets. The findings of D'Imperio (2000), D'Imperio and House (1997) and Makarova (2007) for Neapolitan Italian and Russian that the questions may feature targets that are aligned later than in statements was not borne out by this Welsh data.

The second research question for the alignment data asked whether decreased "space" affected the alignment of the tonal targets. The data show that there were significant alignment adjustments for a number of tonal targets. Firstly, the number of syllables preceding the prenuclear accented syllable was found to affect the alignment of the prenuclear H target in yes-no questions. A similar effect was found for the L2 (end of fall) target in all sentence types. With fewer syllables between the utterance onset and the prenuclear accented syllable, the targets were pushed later. This replicates findings for other languages, for example Dalton and Ní Chasaide (2005) for Irish who also found that reducing the number of preceding syllables appeared to cause prenuclear targets to be pushed later. Furthermore, the number of syllables between the prenuclear and nuclear accented syllables had a significant and gradient effect on the alignment of one target: prenuclear L2. With fewer intervening syllables the tonal target was aligned earlier. This resulted in a plateau of low F0 between the prenuclear L2 and the nuclear L1, which was variable in length as a function of the number of intervening syllables. Nuclear H and L2 were affected by the number of syllables following the nuclear accented syllables (the tail). With a 1 syllable tail, the H and the L2 aligned later than when there was no tail. While the adjustments to the H targets were small, the L2 targets were 89 ms later in the 1 tail condition than in the 0 tail condition. These adjustments for Anglesey Welsh replicate findings by Arvaniti et al. (1998; 2006) who found that nuclear targets appeared earlier in Greek when the number of syllables at the end of the utterance was reduced. That is, increasing the proximity of the utterance end "pushes" the tonal targets leftward.

1.3 Phonology of Anglesey Welsh intonation

Chapter 5 focussed on a phonological analysis of the structure of the intonation patterns for each sentence type following the autosegmental-metrical framework. From the quantitative data in Chapters 3 and 4, all four sentence types show evidence of a) the anchoring of certain targets to segments and b) predictable variation in the alignment of other targets. There was fairly stable alignment of some phonetic targets: prenuclear L1 (start of rise) and prenuclear H (peak), as well as nuclear L1 (start of rise). There was slight variation in the alignment of nuclear H (peak), but in general this target occurred within the accented vowel. There was more variable alignment of the two L2 tonal targets (prenuclear and nuclear). Based on this evidence, it was proposed (in Chapter 5) that due to the overall stability in alignment of the L1 and H targets in *both* prenuclear and nuclear position, the tones appear to group into an L+H* pitch accent across all sentence types. Furthermore, it was suggested that the nuclear leading L was subject to spreading, resulting in a plateau, which was variable in length as a function of the number of syllables intervening between the prenuclear and nuclear accented syllables. Following the nuclear pitch accent, the L target is analysed as a low boundary tone L% that seeks to align close to the end of the utterance. Thus, it was proposed that all four sentence types with two accented syllables could best be represented as L+H* L+H* L%.

2 Implications of findings

The findings of the present study have a number of implications for the field of intonational phonology as well as for further research on Welsh intonation. In the following section, the relevance of the findings is explained in further detail.

2.1 Relevance for theory of intonational phonology

During the investigation, it was found that the L1 and H targets were best analysed as a *right-headed* pitch accent consisting of a leading L tone and a starred H tone (L+H*). A number of researchers would generally reject this analysis due to the fact that their models only permit left-headed pitch accents (e.g. Gussenhoven, 2005; Grabe, 2004). However, given that the L and H target were consistently aligned with the accented syllable and the H more strongly so, L+H* is the most straightforward analysis of this relationship. The L target is suggested to be a salient tone that is associated with the accented syllable given its stable alignment and scaling even in situations of tonal clash.

Leading on from this previous point, this thesis has adopted a bottom-up detailed phonetic investigation that has informed the phonological analysis in Chapter 5. This thesis has rejected the use of a transcription system such as ToBI, ToDI and IViE due to a number of issues with their applications (lack of phonetic specification, lack of comparability across languages). The most important reason for rejecting the use of a transcription system for Anglesey Welsh was that these transcription systems were developed for different languages (ToBI for mainstream American English, ToDI for Dutch and IViE for various varieties of British English), the application of these transcription systems to undescribed varieties or language varieties without prior investigation of the structures present was deemed inadequate. In fact, Beckman et al. (2005: 42) themselves state that the ToBI framework system "devised for one language variety cannot be assumed to be applicable even to other varieties of the same language, without first establishing appropriate intonational and prosodic analyses for each variety". Thus, it is hoped that by investigating the phonological analysis based on the phonetic realisation, this thesis has revealed that there is a clear structure and organisation of the tones into right-headed pitch accents. It is proposed that phonetic approaches to the analysis of intonation investigating the scaling and alignment can provide detailed information about the patterning of tonal targets, precluding the use of an arbitrary labelling system.

2.2 Relevance of findings for Welsh

Regarding the study of Welsh intonation, this thesis has revealed differences between the previous literature and the phonological analysis in the present study. Previous analyses had suggested that there might be a wide range of pitch movements possible in nuclear position. However, the data collected in this thesis suggest that there is *one* nuclear pitch accent which is evident in all four sentence types. Furthermore, Evans (1997) noted that the most common pattern in declaratives in the Cardiff variety of Welsh that she studied was a rise-fall of L* H-L%, with the start of the rise occurring on the penultimate syllable and the ultima containing the peak. This contrasts with the findings for Anglesey Welsh, where the pitch peak was consistently aligned *within* the penultimate syllable.

By investigating the realisation of intonation in Anglesey Welsh controlled and semi-spontaneous speech using instrumental methods, this thesis has raised questions about the relevance of the methods used in previous studies. In Chapter 2 much of the literature on Welsh suprasegmentals was criticised due to the fact that they used non-instrumental methods for the analysis of intonation. Furthermore, the description of speakers and methods in previous studies was generally lacking. As a result, it is not possible to deduce whether differences reported for other studies that contrast with the findings for this study are because of dialect-related differences, age-related differences or simply as a result of the methods used.

3 Recommendations for future research

This thesis has aimed to set a foundation for further research into the understanding of intonation realisation in Welsh in general. As such, the recommendations for future research mainly centre on the application of the AM approach to other varieties of Welsh.

As noted in Chapter 5, research in the field has shown increasing interest in considering cross-variety differences in the realization of intonation. Given that the findings for Anglesey Welsh contrast starkly with the previous reports for Welsh intonation, this thesis should serve as a starting point for further analysis of other varieties of Welsh using similar methods. A large-scale investigation comparing the intonation systems using the same method and framework for analysis would provide a comparative view of the realization of intonation in other varieties. Those comparative studies for other languages such as Grabe (2004), Grabe and Post (2002), Dalton and Ní Chasaide (2005) have found fine differences in the alignment of tonal targets dependent on the variety. Dialectal variation may indeed be an explanation for the stark difference found between the Anglesey Welsh data from the present thesis and the suggestion that a low starred (L*) nuclear accent is the most common pattern found declarative in (other varieties of) Welsh (Evans, 1997; Ball and Williams, 2001).

Furthermore, it would be useful to explore further the phonetic manifestation of stress in different varieties of Welsh. Previous research was criticised in this thesis due to issues with methods, the data used and the suggested analysis. One of the main suggestions of the previous studies (Jones, 1949; Watkins, 1961; Thomas, 1967; Williams, 1985, 1989;

Bosch, 1996) was that there was a separate prominence or *accent* on the ultima in polysyllabic words and *stress* on the penultimate syllable. It was suggested that the penultimate stressed syllable in Welsh was used as the cornerstone of rhythmic organisation, but the usual acoustic correlates of stress (high pitch, greater amplitude, longer duration) were not necessarily found on the penultimate syllable in the varieties of Welsh studied. While the present study did not investigate the acoustic correlates of stress in Welsh, it did find that intonational peaks are aligned consistently with the stressed *penultimate* syllable and the F0 falls onto the following syllable (if present). The observations by previous researchers about the nature of stress in Welsh indicated that the final syllable might feature a pitch peak. However, during data collection, measurement and analysis, there was no evidence of any perceptual or measurable prominence on the ultima in polysyllabic words. It would thus be useful to investigate whether the acoustic manifestation of stress varies across different varieties of Welsh.

Finally, as touched upon in Chapter 5, it would be useful to explore further the accentability of sentential constituents in different varieties of Welsh. In Chapter 3 we saw that the six speakers of Anglesey Welsh varied in the accentuation of certain sentential constituents. We saw that in the periphrastic construction (auxiliary- subject- verb- object) there was no evidence of the accentuation of the non-finite verb. However, in the VSO construction the finite verb was accented by some speakers but was not accented by others. Pursuing the accentability of certain sentential constituents could provide information about prosodic structure. The positioning of pitch accents is viewed by some as a reflection of the utterance's prosodic structure (Ladd, 2008a: 273). Analyses of the prosodic structure of Welsh were not drawn as part of this thesis due to the variability in the accentability of the accented finite verbs in VSO constructions. However, a natural progression would investigate the accentability and prosodic phrasing of constituents in Welsh.

The accentability of a wh-word was also touched upon in Chapter 5. While Watkins (1961) had noted initial high pitch, which could be indicative of a pitch accent on a wh-word, the evidence from the data analysis of Anglesey Welsh suggests that the wh-word is not pitch prominent. During data analysis the onset F0 of the first reliable point in the utterance was labelled and this label was usually placed on the vowel of the wh-word (the wh-words used in data collection were *pam* 'why', *pryd* 'when', *be* 'what' and *lle* 'where'). In fact, it appeared that this initial labelled point in the utterance for wh-questions was actually lower than the prenuclear L1. While this observation is not tested quantitatively, further research could shed light on the accentability of the wh-word (in conditions where the wh-word is not focussed). The methodological issues surrounding this (i.e. the lack of sonorant material in the wh-words in Welsh) could be remedied in future work by adding a preposition before the wh-word. Certain consonants in word-initial position in Welsh can undergo a process of consonant mutation where they change from a radical to a mutated form as a result of certain lexical or grammatical triggers. In wh-questions with *lle* for example, the radical voiceless lateral fricative [ɬ] mutates to the voiced lateral approximant [l] as in:

f) I le mae Manon yn mynd?
to where be.3S.PRES Manon PRT go
"to where is Manon going?"

By adding a preposition such as *o* 'from', *i* 'to', *am* 'about/for', the segmental material would a) be increased and b) be more sonorant as a result of the initial consonant mutation.

Appendix A

Pilot reading list

An exploratory pilot investigation with one male speaker (aged 25) from Menai Bridge was undertaken prior to the main data collection. Below are the reading materials with gloss and translation.

Statements

Mae gan Manon falwen ar ôl.
be.3S.PRES with.3S Manon snail after
'Manon has a snail remaining'

Mae gan Manon falwen.
be.3S.PRES with.3S Manon snail
'Manon has a snail'

Mae gan Manon ful ar ôl.
be.3S.PRES with.3S Manon donkey after
'Manon has a donkey remaining'

Mae gan Manon un malwen ar ôl.
be.3S.PRES with.3S Manon one snail after
'Manon has one snail remaining'

Mae gan Manon un malwen.
be.3S.PRES with.3S Manon one snail
'Manon has one snail'

Mae gan Manon un mul ar ôl.
be.3S.PRES with.3S Manon one donkey after
'Manon has one donkey remaining'

Dydy Manon ddim wedi bod yn y môr o'r blaen.
be.3S.PRES.NEG Manon NEG PRT.PAST be.NONFIN in DET sea of DET front
'Manon hasn't been in the sea before'

Dydy Manon ddim wedi bod yn yr Almaen o'r blaen.
be.3S.PRES.NEG Manon NEG PRT.PAST be.NONFIN in DET Germany of DET front
'Manon hasn't been to Germany before'

Dydy Manon ddim wedi bod yn yr Almaen.
be.3S.PRES.NEG Manon NEG PRT.PAST be.NONFIN in DET Germany
'Manon hasn't been to Germany'

Dydy Manon ddim yn mynd i'r Almaen rŵan. .

be.3S.PRES.NEG Manon NEG PRT go.NONFIN to DET Germany now
'Manon isn't going to Germany now'

Dydy Manon ddim yn mynd i'r Almaen.
be.3S.PRES.NEG Manon NEG PRT go.NONFIN to DET Germany now
'Manon isn't going to Germany'

Dydy Manon ddim yn mynd i'r môr rŵan.
be.3S.PRES.NEG Manon NEG PRT go.NONFIN to DET sea now
'Manon isn't going to the sea now'

Mae Manon wedi bod yn y môr o'r blaen.
be.3S.PRES Manon PRT.PAST be.NONFIN in DET sea of DET front
'Manon has been in the sea before'

Mae Manon wedi bod yn yr Almaen o'r blaen.
be.3S.PRES Manon PRT.PAST be.NONFIN in DET Germany of DET front
'Manon has been to Germany before'

Mae Manon wedi bod yn yr Almaen.
be.3S.PRES Manon PRT.PAST be.NONFIN in DET Germany
'Manon has been in to Germany'

Mae Manon yn mynd i'r Almaen rŵan.
be.3S.PRES Manon PRT go.NONFIN to DET Germany now
'Manon is going to Germany now'

Mae Manon yn mynd i'r Almaen.
be.3S.PRES Manon PRT go.NONFIN to DET Germany
'Manon is going to Germany'

Mae Manon yn mynd i'r môr rŵan.
be.3S.PRES Manon PRT go.NONFIN to DET sea now
'Manon is going to the sea now'

Yes-no questions

Aeth Manon i'r Almaen ddoe?
go.3S.PAST Manon to DET Germany yesterday
'Did Manon go to Germany yesterday?'

Aeth Manon i'r Almaen?
go.3S.PAST Manon to DET Germany yesterday
'Did Manon go to Germany?'

Oes gan Manon falwen ar ôl?
be.3S.PRES with.3S Manon snail after
'Has Manon got a snail remaining?'

Oes gan Manon falwen?

be.3S.PRES with.3S Manon snail
'Has Manon got a snail?'

Oes gan Manon ful ar ôl?
be.3S.PRES with.3S Manon donkey after
'Has Manon got a donkey remaining?'

Oes gan Manon un malwen ar ôl?
be.3S.PRES with.3S Manon one snail after
'Has Manon got one snail remaining?'

Oes gan Manon un malwen?
be.3S.PRES with.3S Manon one snail after
'Has Manon got one snail?'

Oes gan Manon un mul ar ôl?
be.3S.PRES with.3S Manon one snail after
'Has Manon got a donkey remaining?'

Wnaeth Manon fynd i'r Almaen?
do.3S.PAST Manon go.NONFIN to DET Germany
'Did Manon go to Germany?'

Wnaeth Manon fynd i'r Almaen ddoe?
do.3S.PAST Manon go.NONFIN to DET Germany yesterday
'Did Manon go to Germany yesterday?'

Wnaeth Elwyn fynd i'r felin ddoe?
do.3S.PAST Manon go.NONFIN to DET mill yesterday
'Did Elwyn go to the mill yesterday?

Ydy Manon wedi bod yn y môr o'r blaen?
be.3S.PRES Manon PRT.PAST be.NONFIN in DET sea of DET front
'Has Manon been in the sea before?'

Ydy Manon yn mynd i'r Almaen?
be.3S.PRES Manon PRT go.NONFIN to DET Germany
'Is Manon going to Germany?'

Ydy Manon wedi bod yn yr Almaen?
be.3S.PRES Manon PRT.PAST be.NONFIN in DET Germany
'Has Manon been to Gerany?'

Ydy Manon yn mynd i'r Almaen rŵan?
be.3S.PRES Manon PRT go.NONFIN to DET Germany now
'Is Manon going to Germany now?'

Ydy Manon wedi bod yn yr Almaen o'r blaen?
be.3S.PRES Manon PRT.PAST be.NONFIN in DET Germany of DET front

'Has Manon been to Germany before?'

Ydy Manon yn mynd i'r môr rŵan?
be.3S.PRES Manon PRT go.NONFIN to DET sea now
'Is Manon going to the sea now?'

Wh-questions

Pam mae Manon yn mynd i'r Almaen rŵan?
why be.3S.PRES Manon PRT go.NONFIN to DET Germany now
'Why is Manon going to Germany now?'

Pam mae Manon yn mynd i'r Almaen?
why be.3S.PRES Manon PRT go.NONFIN to DET Germany
'Why is Manon going to Germany?'

Pam mae Manon yn mynd i'r môr rŵan?
why be.3S.PRES Manon PRT go.NONFIN to DET sea now
'Why is Manon going to the sea now?'

Pam dydy Manon ddim wedi bod yn y môr o'r blaen?
why be.3S.PRES.NEG Manon NEG PRT.PAST be.NONFIN in DET sea of DET front
'Why hasn't Manon been in the sea before?'

Pam dydy Manon ddim wedi bod yn yr Almaen o'r blaen?
why be.3S.PRES.NEG Manon NEG PRT.PAST be.NONFIN in DET Germany of DET front
'Why hasn't Manon been to Germany before?'

Pam dydy Manon ddim wedi bod yn yr Almaen?
why be.3S.PRES.NEG Manon NEG PRT.PAST be.NONFIN in DET Germany
'Why hasn't Manon been to Germany?'

Pam dydy Manon ddim yn mynd i'r Almaen rŵan?
why be.3S.PRES.NEG Manon NEG PRT go.NONFIN in DET Germany now
'Why isn't Manon going to Germany now?'

Pam dydy Manon ddim yn mynd i'r Almaen?
why be.3S.PRES.NEG Manon NEG PRT go.NONFIN in DET Germany
'Why isn't Manon going to Germany?'

Pam dydy Manon ddim yn mynd i'r môr rŵan?
why be.3S.PRES.NEG Manon NEG PRT go.NONFIN in DET sea now
'Why isn't Manon going to the sea now?'

Pam oes gan Manon falwen ar ôl?
why be.3S.PRES with.3S Manon snail after
'Why has Manon got a snail remaining?'

Pam oes gan Manon falwen?
why be.3S.PRES with.3S Manon snail

‘Why has Manon got a snail?

Pam oes gan Manon ful ar ôl?
why be.3S.PRES with.3S Manon donkey after
‘Why has Manon got a donkey remaining?’

Pam oes gan Manon un malwen ar ôl?
why be.3S.PRES with.3S Manon one snail after
‘Why has Manon got one snail remaining?’

Pam oes gan Manon un malwen?
why be.3S.PRES with.3S Manon one snail
‘Why has Manon got one snail?’

Pam oes gan Manon un mul ar ôl?
why be.3S.PRES with.3S Manon one donkey after
‘Why has Manon got one donkey remaining?’

Pryd mae Manon wedi bod yn y môr o'r blaen?
when be.3S.PRES Manon PRT.PAST be.NONFIN in DET sea of DET front
‘When has Manon been in the sea before?’

Pryd mae Manon wedi bod yn yr Almaen o'r blaen?
when be.3S.PRES Manon PRT.PAST be.NONFIN in DET Germany of DET front
‘When has Manon been to Germany before?’

Pryd mae Manon wedi bod yn yr Almaen?
when be.3S.PRES Manon PRT.PAST be.NONFIN in DET Germany
‘When has Manon been to Germany?’

Appendix B

Material design

1 Dialogue Reading Task

<u>Statements</u>

Mae hi'n bwrw eira tu allan. ‘It’s snowing outside.’
Mae'r eira yn wyn. The snow is white.
be.3S.PRES DET snow PRT white
[maɨr ˈəɨra ən wɨn]

Mae ‘na lysiau i ginio. ‘There are vegetables for lunch.’
Dydy Manon ddim yn licio moron. ‘Manon doesn’t like carrots.’
be.3S.PRES.NEG Manon NEG PRT like.NONFIN carrots
[dədɨ ˈmanɔn ðɪm ən ˈlɪkjɔ ˈmɔrɔn]

Mae pawb yn drist. ‘Everybody is sad.’
Mae Non yn mynd i'r angladd. ‘Non is going to the funeral.’
be.3S.PRES Non PRT go.NONFIN to DET funeral
[maɨ nɔn ən mɨnd ɪr ˈaŋlað]

Maen nhw wedi hel pres at achos da. ‘They have raised money for a good cause.’
Mi ddringodd Manon fynydd ‘Manon climbed a mountain.’
PRT climb.3S.PAST Manon mountain
[mɪ ˈðrɪŋɔð ˈmanɔn ˈvənɨð]

Maen nhw yn cael ysgariad ‘They are having a divorce.’
Roedd Manon yn caru Wil. ‘Manon loved Wil.’
be.3S.PAST Manon PRT love.NONFIN Wil
[rɔɨð ˈmanɔn ən karɨ wil]

Maen nhw yn hel pres. ‘They are raising money.’
Mae Non yn dringo mynydd. ‘Non is climbing a mountain.’
be.3S.PRES Non PRT climb.NONFIN mountain
[maɨ nɔn ənˈðrɪŋɔ ˈmənɨð]

Mae'r plant wedi bod yn ddrwg. ‘The children have been naughty.’
Mi wnaeth Manon siarad efo Ann. ‘Manon spoke to Ann.’
PRT do.3S.PAST Manon speak.NONFIN with Ann
[mɪ naθ ˈmanɔn ʃarad ɛvɔ an]

Mae'r plant yn cael mêl. ‘The children are having honey.’
Dydy Manon ddim yn licio mêl. ‘Manon doesn’t like honey.’
be.3S.PRES.NEG Manon NEG PRT like.NONFIN honey
[dədɨ ˈmanɔn ðɪm ən ˈlɪkjɔ mel]

Mi wnaeth y gennod fynd hebddi hi.
Roedd Non yn flin.
be.3S.PAST Non PRT angry
[rɔɨð nɔn ən vlin]
‘The girls went without her.’
‘Non was angry.’

Oes 'na ddigon o le i barcio?
Mae'r lon yn eang.
be.3S.PRES DET road PRT wide
[maɨɾ lon ən 'eaŋ]
‘Is there enough space to park?’
‘The road is wide’

Pa fenig ‘sgen ti?
Mae'r menig yn oren.
be.3S.PRES DET gloves PRT orange
[maɨɾ ˈmɛnɪg ən ˈɔɾɛn]
‘Which gloves have you got?’
‘The gloves are orange.’

Pa fenyn ti isio?
Mae'r menyn yn felyn.
be.3S.PRES DET butter PRT yellow
[maɨɾ ˈmɛnɨn ən ˈvɛlɨn]
‘What butter would you like?’
‘The butter is yellow.’

Roedd hi'n cerdded i lawr y stryd
Mi welodd Manon Wil.
PRT see.3S.PAST Manon Wil
[mɪ ˈwɛlɔð ˈmanɔn wil]
‘She was walking down the street.’
‘Manon saw Will.’

Sut mae'r gwesty?
Mae'r gwely yn feddal.
be.3S.PRES DET bed PRT soft
[maɨɾ ˈgwɛlɨ ən ˈvɛðal]
‘How’s the hotel?’
‘The bed is soft.’

Ydw i'n iawn i ddechrau coginio?
Mae'r moron yn lân.
be.3S.PRES DET carrots PRT clean
[maɨɾ ˈmɔɾɔn ən ˈlɑn]
‘Am I okay to start cooking?’
‘The carrots are clean.’

Wh-Questions

Mae Nain Huw wedi marw.
Pam mae Manon yn mynd i'r angladd?
why be.3S.PRES Manon PRT go.NONFIN to DET funeral
[pam maɨ ˈmanɔn ən mɨnd iɾ ˈaŋlað]
‘Huw’s grandma has died.’
‘Why is Manon going to the funeral?’

Maen nhw wedi bod yn teithio am flynyddoedd.
Pryd wnaeth Manon fynd i'r Almaen?
when do.3S.PAST Manon go.NONFIN to DET Germany
[prɨd naθ ˈmanɔn vɨnd iɾ almaɨn]
‘They have been travelling for years.’
‘When did Manon go to Germany?’

Mae'r plant wedi torri'r ffenest. ‘The children have broken the window.’

Pam doedd Manon ddim yn flin? ‘Why wasn’t Manon angry?’
why be.3S.PAST.NEG Manon NEG PRT angry
[pam dɔɨð ˈmanɔn ðɪm ən vlin]

Be mae Manon yn feddwl? ‘What does Manon mean?’
what be.3S.PRES Manon PRT mean.NONFIN
Mae hi isio cael ysgariad. ‘She wants a divorce.’
[bɛ maɨ ˈmanɔn ən vɛðʊl]

Lle welodd Manon Nel? ‘Where did Manon see Nel?’
where see.3S.PAST Manon Nel
Yn y dafarn. ‘In the pub.’
[ɬe wɛlɔð ˈmanɔn nɛl]

Lle wnaeth Elwyn siarad efo Wil? ‘Where did Elwyn speak to Wil?’
where do.3S.PAST Elwyn speak.NONFIN with Wil
Yn y siop esgidiau. ‘In the shoe shop.’
[ɬe naθ ˈɛlwɨn ʃaɾad ɛvɔ wil]

Pam doedd y lolfa ddim yn lân? ‘Why wasn’t the lounge clean?’
why be.3S.PAST.NEG DET lounge NEG PRT clean
Mae'r plant wedi cael parti ‘The children have had a party.’
[pam dɔɨð ə ˈlɔlfa ðɪm ən lɑn]

Pam dydy Non ddim yn licio menyn? ‘Why doesn’t Non like butter?’
why be.3S.PRES.NEG Non NEG PRT like.NONFIN butter
Dydy hi ddim yn licio'r blas. ‘She doesn’t like the taste.’
[pam dədɨ nɔn ðɪm ən ˈlɪkjɔ ˈmɛnɨn]

Pam mae Manon yn mynd? ‘Why is Manon going?’
why be.3S.PRES Manon PRT go.NONFIN
Dydy hi ddim isio priodi fo. ‘She doesn’t want to marry him.’
[pam maɨ ˈmanɔn ən mɨnd]

Pam mae'r afal yn feddal? ‘Why is the apple soft?’
why be.3S.PRES DET apple PRT soft
Maen nhw wedi bod yn y bowlen am wythnosau. ‘They’ve been in the bowl for weeks.’
[pam maɨɾ ˈaval ən ˈvɛðal]

Pam oedd y lon ar gau? ‘Why was the road closed?’
why be.3S.PAST DET road closed
Roedd 'na lifogydd. ‘There were floods.’
[pam ɔɨð ə lon aɾ gaɨ]

Pam oes gan Anwen iâr? ‘Why has Anwen got a chicken?’
why be.3S.PRES with.3S Anwen chicken
Mae hi'n licio wyau ‘She likes eggs.’
[pam ɔɨs gan ˈanwɛn jɑɾ]

Pryd mae Manon yn dringo mynydd? ‘When is Manon climbing a mountain?’
when be.3S.PRES Manon PRT climb.NONFIN mountain
Wythnos nesa ‘Next week.’
[prɨd maɨ ˈmanɔn ən drɪŋɔ ˈmənɨð]

<u>**Yes-no questions**</u>

Mae Nain wedi marw. ‘Grandma has died.’
Ydy Manon yn mynd i'r angladd? ‘Is Manon going to the funeral?’
be.3S.PRES Manon PRT go.NONFIN to DET funeral
[ədɨ ˈmanɔn ən mɨnd iɾ ˈaŋlað]

Mae'r plant wedi dechrau bwyta llysiau. ‘The children have started to eat vegetables’
Ydy Wil yn bwyta moron? ‘Does Wil eat carrots?’
be.3S.PRES Wil PRT eat.NONFIN carrots
[ədɨ wil ən bɨta ˈmɔɾɔn]

Mi aethon ni i'r traeth heddiw. ‘We went to the beach today.’
Aeth Wil i'r môr? ‘Did Wil go to the sea?’
go.3S.PAST Wil to DET sea
[aθ wil iɾ moɾ]

Mi enillodd y syndicate y loteri. ‘The syndicate won the lottery.’
Enillodd Elwyn fil? ‘Did Elwyn win a thousand?’
win.3S.PAST Elwyn thousand
[ɛnɪɬɔð ˈɛlwɨn fil]

Mi wnaeth Elen farw mis diwetha’. ‘Elen died last month.’
Wnaeth Elwyn fynd i'r angladd? ‘Did Elwyn go to the funeral?’
do.3S.PAST Elwyn go.NONFIN to DET funeral
[naθ ˈɛlwɨn fɨnd iɾ ˈaŋlað]

Roedd 'na ddamwain. ‘There was an accident.’
Oedd Non yn iawn? ‘Was Non okay?’
be.3S.PAST Non PRT okay
[ɔɨð nɔn ən jaʊn]

Oedd Manon yn dawel? ‘Was Manon quiet?’
be.3S.PAST Manon PRT quiet
Oedd, dw i ddim yn gwybod pam. ‘Yes, I don’t know why.’
[ɔɨð ˈmanɔn ən ˈdaʊɛl]

Oedd y ddrama yn dda? ‘Was the drama good?’
be.3S.PAST DET drama PRT good
Oedd, wnes i fwynhau ‘Yes, I enjoyed (myself/it).’
[ɔɨð ə ˈðɾama ən ða]

Oedd y mafon yn felys? ‘Were the raspberries sweet?’
be.3S.PAST DET raspberries PRT sweet
Oedden. ‘Yes.’
[ɔɨð ə ˈmavɔn ən ˈvɛlɨs]

Ydy Elwyn wedi bwyta'r moron? ‘Has Elwyn eaten his carrots?’
be.3S.PRES Elwyn PRT.PAST eat.NONFIN DET carrots
Do, mae o'n licio llysiau rŵan. ‘Yes, he likes vegetables now.’
[ˈədɨ ˈɛlwɪn ˈwɛdi ˈbɪtaɾ ˈmɔɾɔn]

Ydy'r afal yn lân? ‘Is the apple clean?’
be.3S.PRES DET apple PRT clean
Ydy, mae'n iawn i fwyta. ‘Yes, it’s okay to eat.’
[ˈədɨɾ ˈaval ən ˈlɑn]

Ydy'r mafon yn felys? ‘Are the raspberries sweet?’
be.3S.PRES DET raspberries PRT sweet
Ydyn. ‘Yes.’
[ˈədɨɾ ˈmavɔn ən ˈvɛlɨs]

Ydy'r mul yn wyn? ‘Is the donkey white?’
be.3S.PAST DET donkey PRT white
Nac ydy, mae o'n ddu. ‘No, it’s black.’
[ˈədiɾ ˈmɨl ən wɪn]

<u>Declarative Questions (paired with matching statements)</u>

Dydy Manon ddim yn licio mêl? ‘Manon doesn’t like honey?’
be.3S.PRES.NEG Manon NEG PRT like.NONFIN honey
Don i ddim yn gwybod hynny ‘I didn’t know that.’
[dədɨ ˈmanɔn ðɪm ən ˈlɪkjɔ mel]

Dydy Manon ddim yn licio moron? ‘Manon doesn’t like carrots?’
be.3S.PRES.NEG Manon NEG PRT like.NONFIN carrots
Don i ddim yn gwybod hynny ‘I didn’t know that.’
[dədɨ ˈmanɔn ðɪm ən ˈlɪkjɔ ˈmɔɾɔn]

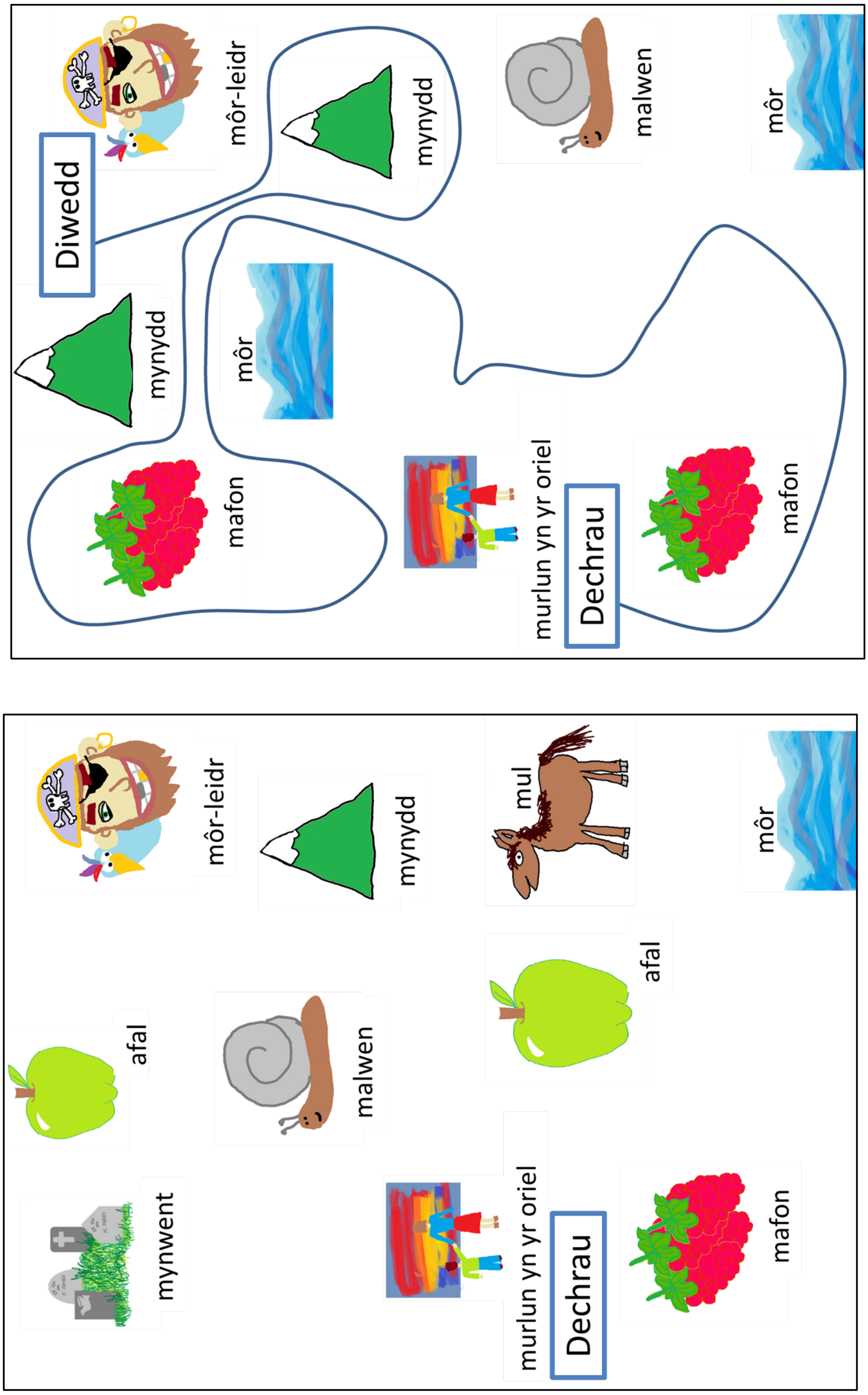
Mae Non yn dringo mynydd? ‘Non is climbing a mountain?’
be.3S.PRES Non PRT climb.NONFIN mountain
Dw i'n synnu am hynny. ‘I’m surprised about that.’
[maɨ nɔn ənˈðɾɪŋɔ ˈmənɨð]

Mae Non yn mynd i'r angladd? ‘Non is going to the funeral?’
be.3S.PRES Non PRT go.NONFIN to DET funeral
Dw i'n synnu am hynny. ‘I’m surprised about that.’
[maɨ nɔn ən mɨnd iɾ ˈaŋlað]

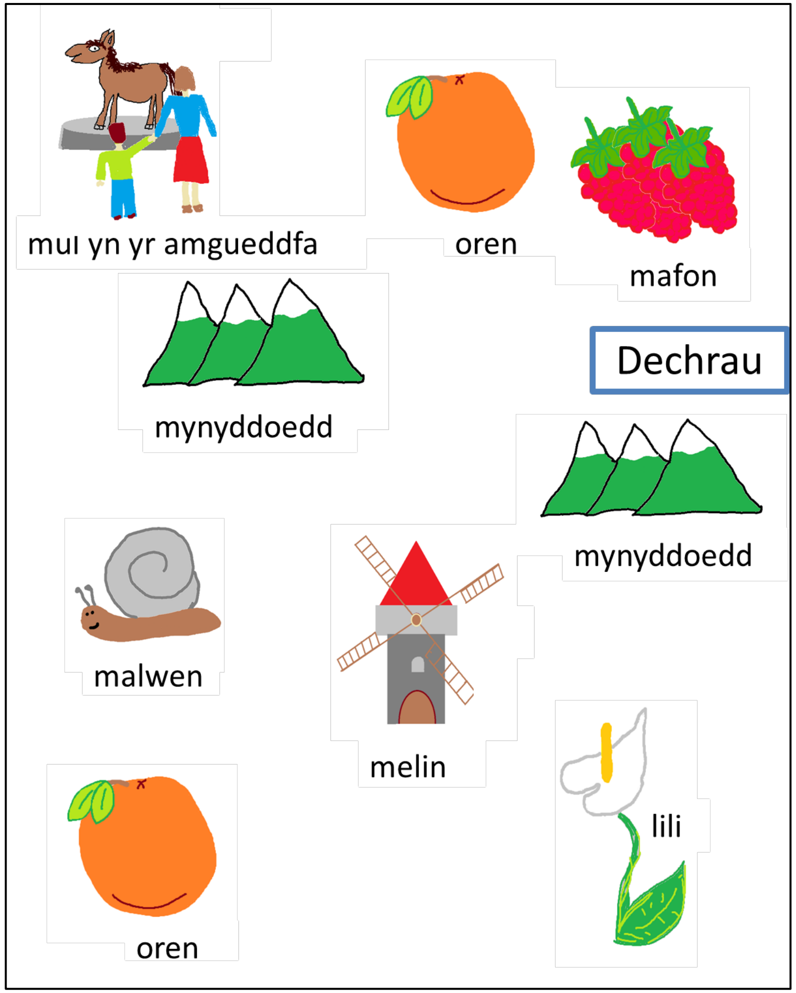
Mae'r eira yn wyn?	The snow is white?
be.3S.PRES DET snow PRT white	
Ydy, mae'r eira yn wyn. Da iawn ti!	‘Yes, the snow is white. Well done you!’
[maɨɾ ˈəɨɾa ən wɨn]	
Mae'r gwely yn feddal?	‘The bed is soft?’
be.3S.PRES DET bed PRT soft	
Dwi'n synnu am hynny.	‘I’m surprised about that.’
[maɨɾ ˈgwɛlɨ ən ˈvɛðal]	
Mae'r lon yn eang?	‘The road is wide?’
be.3S.PRES DET road PRT wide	
Mae hynny yn iawn.	‘That’s okay.’
[maɨɾ lon ən 'eaŋ]	
Mae'r menig yn oren?	‘The gloves are orange?’
be.3S.PRES DET gloves PRT orange	
Dwi'n synnu am hynny.	‘I’m surprised about that.’
[maɨɾ ˈmɛnɪg ən ˈɔɾɛn]	
Mae'r menyn yn felyn?	‘The butter is yellow?’
be.3S.PRES DET butter PRT yellow	
Don i ddim yn gwybod hynny	‘I didn’t know that.’
[maɨɾ ˈmɛnɨn ən ˈvɛlɨn]	
Mae'r moron yn lân?	‘The carrots are clean?’
be.3S.PRES DET carrots PRT clean	
Ydyn, dw i wedi paratoi'r llysiau yn barod	‘Yes, I’ve prepared the vegetables already’
[maɨɾ ˈmɔɾɔn ən ˈlɑn]	
Mi ddringodd Manon fynydd?	‘Manon climbed a mountain?’
PRT climb.3S.PAST Manon mountain	
Don i ddim yn gwybod hynny	‘I didn’t know that.’
[mɪ ˈðrɪŋɔð ˈmanɔn ˈvənɨð]	
Mi welodd Manon Wil?	‘Manon saw Will?’
PRT see.3S.PAST Manon Wil	
Don i ddim wedi clywed hynny!	‘I hadn’t heard that!’
[mɪ ˈwɛlɔð ˈmanɔn wil]	
Mi wnaeth Manon siarad efo Ann?	‘Manon spoke to Ann?’
PRT do.3S.PAST Manon speak.NONFIN with Ann	
Mae hyn yn ddiddorol.	‘That’s interesting.’
[mɪ naθ ˈmanɔn ʃaɾad ɛvɔ an]	
Roedd Manon yn caru Wil?	‘Manon loved Wil?’
be.3S.PAST Manon PRT love.NONFIN Wil	
Don i ddim yn gwybod hynny.	‘I didn’t know that.’
[rɔɨð ˈmanɔn ən karɨ wil]	

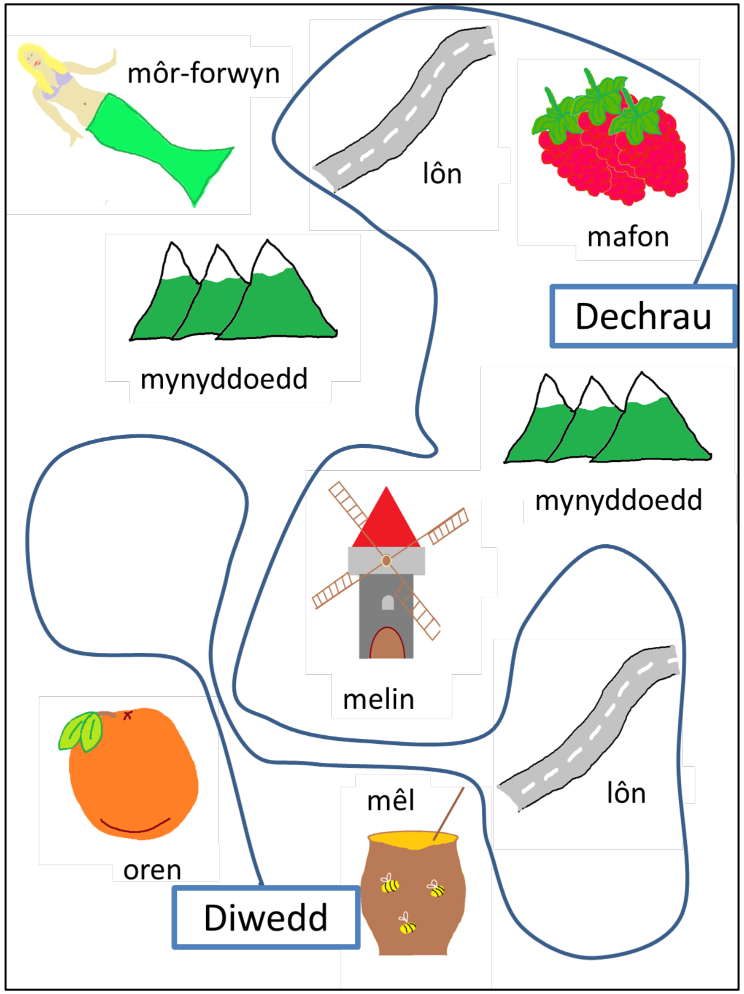
Roedd Non yn flin? 'Non was angry?'
be.3S.PAST Non PRT angry
Dw i'n synny am hynny. 'I'm surprised about that.'
[rɔɨð nɔn ən vlin]

2 Map Task Design



Map Set 1 (Instruction follower - left, Instruction giver - right)





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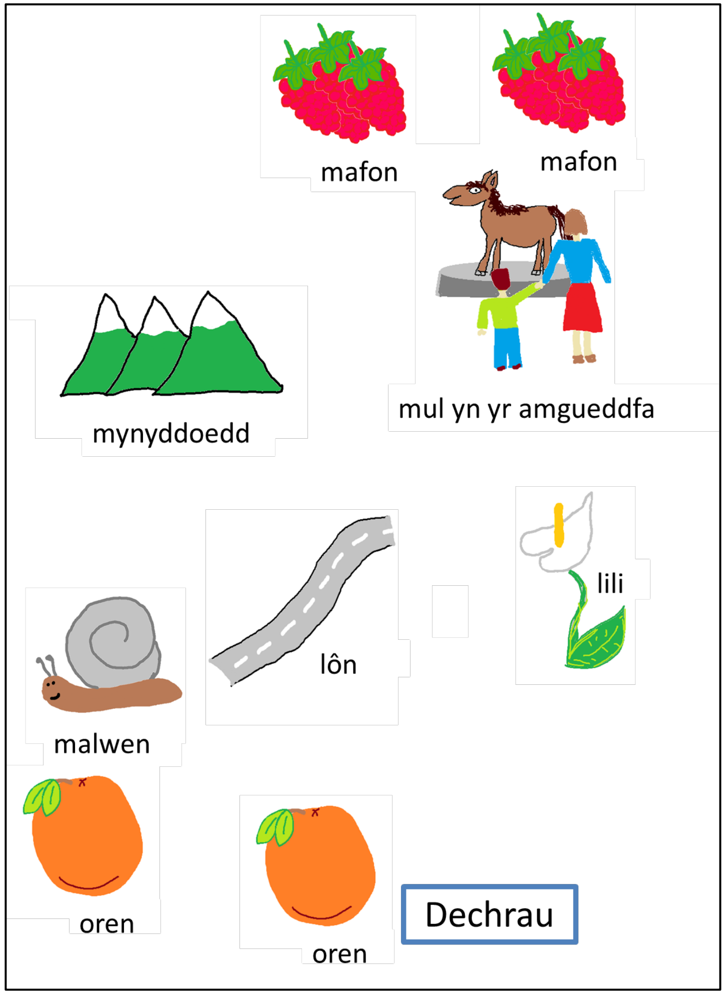
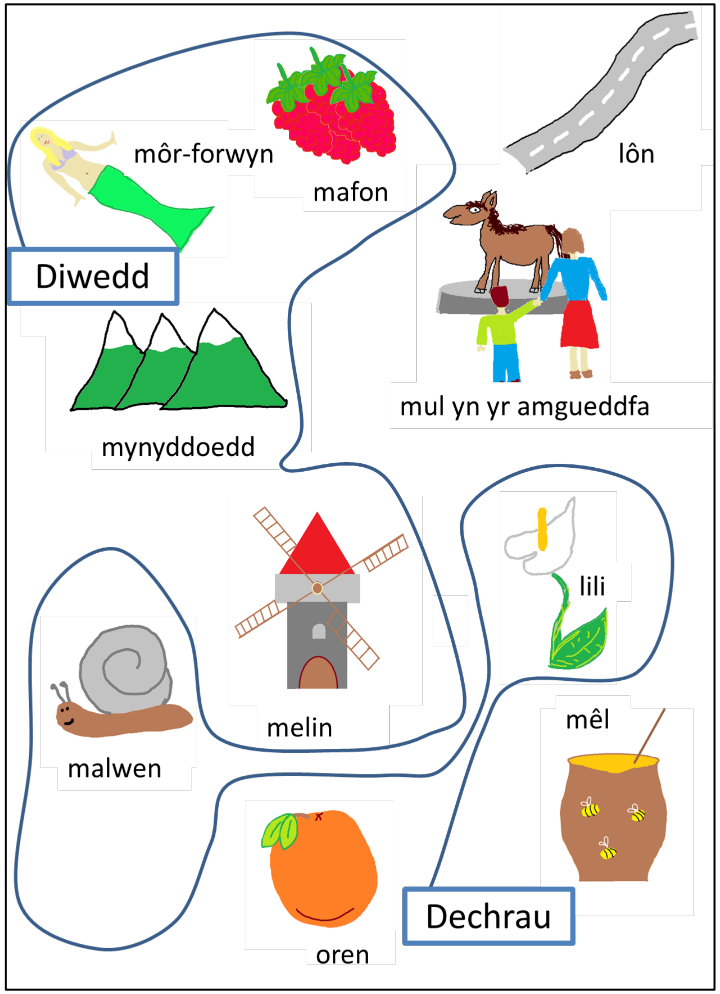
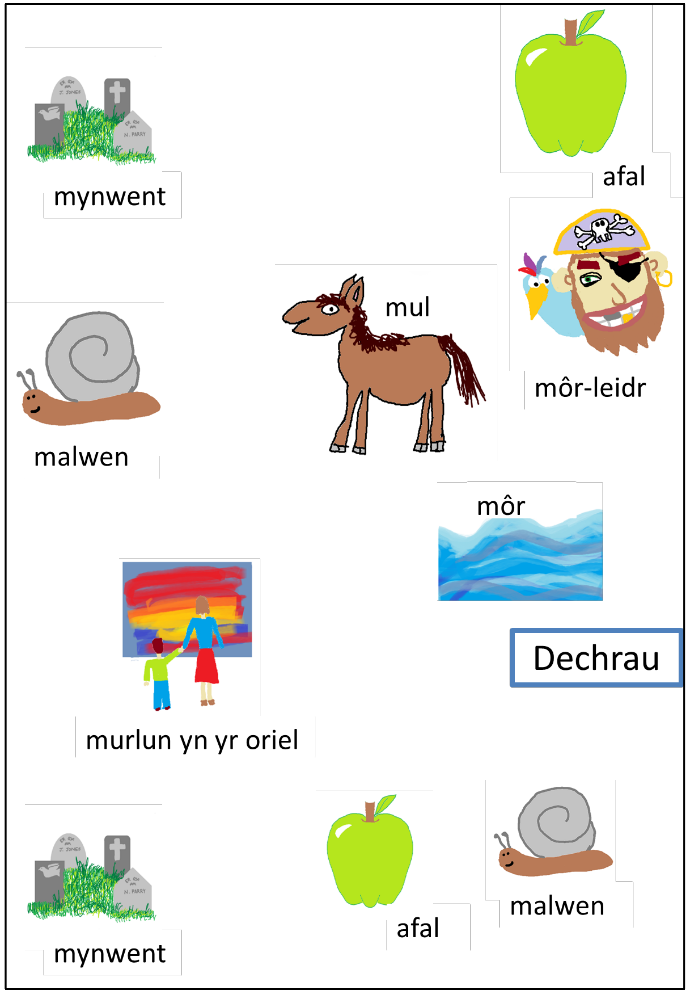
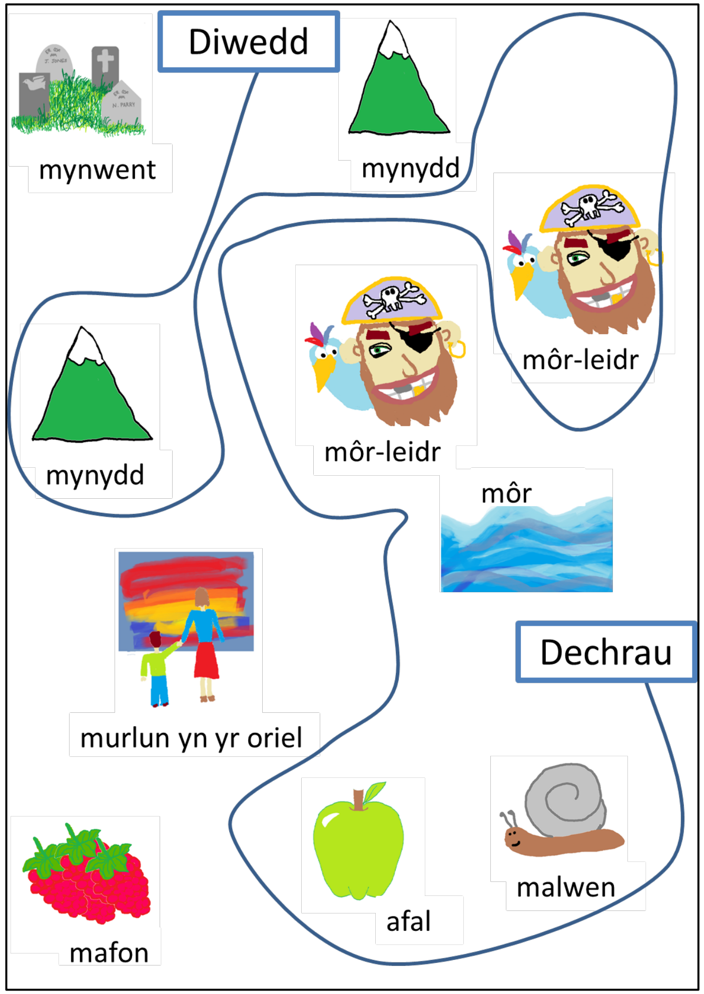




<u>Map Set 3</u> (Instruction follower - left, Instruction giver - right)





<u>Map Set 4</u> (Instruction follower - left, Instruction giver - right)

Appendix C

Participant background questionnaire and responses

Participant ID (To be filled by the experimenter) ________

1. Age ________

2. How long have you lived in North Wales?

Since when I was 2 years old or younger
Since when I was 4 years old or younger
Since primary school
Since secondary school

3. When did you start speaking Welsh?

Since when I was 2 years old or younger
Since when I was 4 years old or younger
Since primary school
Since secondary school

4. How well you think you speak and understand spoken Welsh?

I know very little or no Welsh at all
I know a few basic words and phrases only
I am quite confident in everyday conversations
Can easily take part in complex discussions

5. How well you think you read and write Welsh?

Have little or no ability to read or write
Can read or write some basic words and phrases
Can read or write everyday things
(e.g. emails, read newspaper articles)
I am confident in reading more complex material
(e.g. academic writing or long novels)

Rhif Adnabod Cyfranogwr (I'w lenwi gan yr arbrofwr)

1. Oed

2.Ers faint ydych chi wedi byw yng Ngogledd Cymru?

Ers pan oeddwn i'n 2 oed neu iau
Ers pan oeddwn i'n 4 oed neu iau
Ers ysgol gynradd
Ers ysgol uwchradd

3. Pryd wnaethoch chi ddechrau siarad Cymraeg?

Ers pan oeddwn i'n 2 oed neu iau
Ers pan oeddwn i'n 4 oed neu iau
Ers ysgol gynradd
Ers ysgol uwchradd

4. Pa mor dda ydych chi'n meddwl y gellwch siarad a deall Cymraeg llafar?

Dwi'n medru ychydig iawn neu ddim Cymraeg
Dwi'n gwybod ychydig eiriau a chymalau sylfaenol yn unig
Dwi'n bur hyderus gyda sgyrsiau bob dydd
Gallaf gymryd rhan yn hawdd mewn trafodaethau cymhleth

5. Pa mor dda ydych chi'n meddwl y gellwch ddarllen ac ysgrifennu Cymraeg?

Does gen i fawr ddim neu ddim gallu i ddarllen ac ysgrifennu
Gallaf ddarllen neu ysgrifennu rhai geiriau a chymalau sylfaenol
Gallaf ddarllen neu ysgrifennu pethau bob dydd
(e.e. negeseuon e-bost, erthyglau papur newydd)
Rwy'n gallu darllen deunydd mwy cymhleth yn hyderus
(e.e. gwaith academaidd neu nofelau hir)

6. How well you think you speak and understand spoken English?

I know very little or none
I know a few basic words and phrases only
I am quite confident in everyday conversations
Can easily take part in complex discussions

7. How well you think you read and write English?

Have little or no ability to read or write
Can read or write some basic words and phrases
Can read or write everyday things (e.g. emails, read newspaper articles)
I am confident in reading more complex material (e.g. academic writing or long novels)

8. What language(s) did your mother speak to you when you were a child (if this applies)?

Welsh
English
Welsh and English equally
Other (Please specify) ... ...
Not applicable

9. What language(s) did your father speak to you when you were a child (if this applies)?

Welsh
English
Welsh and English equally
Other (Please specify) ... ...
Not applicable

6. Pa mor dda ydych chi’n meddwl y gellwch siarad a deall Saesneg llafar?

Dwi’n medru ychydig iawn neu ddim
Dwi’n gwybod ychydig eiriau a chymalau sylfaenol yn unig
Dwi’n bur hyderus gyda sgyrsiau bob dydd
Gallaf gymryd rhan yn hawdd mewn trafodaethau cymhleth

7. Pa mor dda ydych chi’n meddwl y gellwch ddarllen ac ysgrifennu Saesneg?

Does gen i fawr ddim neu ddim gallu i ddarllen ac ysgrifennu
Gallaf ddarllen neu ysgrifennu rhai geiriau a chymalau sylfaenol
Gallaf ddarllen neu ysgrifennu pethau bob dydd (e.e. negeseuon e-bost, erthyglau papur newydd)
Rwy’n gallu darllen deunydd mwy cymhleth yn hyderus (e.e. gwaith academaidd neu nofelau hir)

8. Pa iaith/ieithoedd oedd eich mam yn siarad â chi pan oeddech yn blentyn (os yw hynny’n berthnasol)?

Cymraeg
Saesneg
Cymraeg a Saesneg yn gyfartal
Arall (nodwch) ... ...
Amherthnasol

9. Pa iaith/ieithoedd oedd eich tad yn siarad â chi pan oeddech yn blentyn (os yw hynny’n berthnasol)?

Cymraeg
Saesneg
Cymraeg a Saesneg yn gyfartal
Arall (nodwch) ... ...
Amherthnasol

10. What language(s) did any guardians or child minders speak with you (if this applies)?
Welsh
English
Welsh and English equally
Other (Please specify) ... ...
Not applicable

11. In what language(s) did you get your teaching mainly at primary school?
Welsh
English
Welsh and English equally
Other (Please specify) ... ...
Not applicable

12. In what language(s) did you get your learning primarily in secondary school?
Welsh
English
Welsh and English equally
Other (Please specify) ... ...
Not applicable

10. Pa iaith/ieithoedd oedd unrhyw warcheidwaid neu ofalwyr plant yn siarad â chi (os yw hynny'n berthnasol)?
Cymraeg
Saesneg
Cymraeg a Saesneg yn gyfartal
Arall (nodwch) ... ...
Amherthnasol

11. Ym mha iaith/ieithoedd y cawsoch eich dysgu'n bennaf yn yr ysgol gynradd?
Cymraeg
Saesneg
Cymraeg a Saesneg yn gyfartal
Arall (nodwch) ... ...
Amherthnasol

12. Ym mha iaith/ieithoedd y cawsoch eich dysgu'n bennaf yn yr ysgol uwchradd?
Cymraeg
Saesneg
Cymraeg a Saesneg yn gyfartal
Arall (nodwch) ... ...
Amherthnasol

Responses from questionnaire

For ‘length of time in North Wales’ and ‘age started speaking Welsh’, <2 means that the participant lived in North Wales and were exposed to Welsh from under the age of 2. For the ability questions, the responses were graded between 1 and 5, with 5 being *Can easily take part in complex discussions and write complex material* and 1 being *very little or no speaking, reading or writing ability*.

ID	**M1S**	**F2C**	**F3E**	**M5G**	**M4I**	**M6O**
Gender	Male	Female	Female	Male	Male	Male
Age	24	24	29	26	24	24
Length of time in North Wales	<2	<2	<2	<2	<2	<2
Age started speaking Welsh	<2	<2	<2	<2	<2	<2
Ability speaking / understanding Welsh	4	4	3	4	4	4
Ability reading and writing Welsh	4	4	3	4	4	3
Ability speaking and understanding English	4	4	3	4	4	4
Ability reading and writing Welsh	4	4	3	4	4	4
Mother language	Welsh/ English	Welsh	Welsh	Welsh	Welsh	Welsh
Father language	English	Welsh	Welsh	Welsh	Welsh	English
Guardian/Child-minder language	English	Welsh	NA	Welsh	NA	Welsh/ English
Primary School Teaching	Welsh	Welsh	Welsh	Welsh	Welsh	Welsh
Secondary School Stream	Welsh	Welsh	Welsh	Bilingual	Welsh	Bilingual

Appendix D

Statistical tests for Scaling Chapter

1 Scaling of prenuclear L1, H and L2

1.1 MANOVA results (significant effect marked with *)

MANOVA results: scaling of prenuclear L1, H and L2							
Independent Variable	Dependent Variable	Sum of squares	df	Mean Square	F	Sig.	
SType	L1	10920.488	3	3640.163	19.674	.000	*
	H	18144.74	3	6048.247	25.858	.000	*
	L2	44923.476	3	14974.492	98.661	.000	*
Preceding	L1	1036.252	2	518.126	2.8	.062	
	H	498.257	2	249.128	1.065	.346	
	L2	113.591	2	56.796	0.374	.688	
Between	L1	1153.749	5	230.75	1.247	.287	
	H	2157.211	5	431.442	1.845	.104	
	L2	293.774	5	58.755	0.387	.857	
Preceding * Between	L1	265.227	4	66.307	0.358	.838	
	H	304.566	4	76.141	0.326	.861	
	L2	381.431	4	95.358	0.628	.643	
Preceding * Between	L1	439.694	2	219.847	1.188	.306	
	H	351.653	2	175.827	0.752	.473	
	L2	405.898	2	202.949	1.337	.264	
Error	L1	51990.904	281	185.021			
	H	65726.492	281	233.902			
	L2	42649.245	281	151.777			
Total	L1	556107.944	313				
	H	986805.215	313				
	L2	472515.326	313				

1.1 Descriptive statistics and pairwise comparisons for significant effect SENTENCE TYPE

Mean and standard error based on SENTENCE TYPE			
Dependent Variable	SType	Mean	Std. Error
L1	ST	24.28	1.788
	YQ	38.32	2.491
	WQ	51.17	1.727
	DQ	40.19	1.842
H	ST	34.67	2.010
	YQ	51.38	2.801
	WQ	65.22	1.942
	DQ	57.65	2.071
L2	ST	15.26	1.619
	YQ	45.14	2.256
	WQ	23.25	1.564
	DQ	50.17	1.668

Tukey HSD Pairwise comparison for SENTENCE TYPE						
Dependent Variable	Stype	Stype	Mean Difference	Std. Error	Sig.	
L1	ST	YQ	-13.26	2.320	.000	*
		DQ	-16.06	2.051	.000	*
	YQ	DQ	-2.80	2.330	.626	
	WQ	ST	24.88	2.089	.000	*
		YQ	11.62	2.364	.000	*
		DQ	8.82	2.100	.000	*
H	ST	YQ	-14.97	2.609	.000	*
		DQ	-22.22	2.306	.000	*
	YQ	DQ	-7.26	2.620	.030	*
	WQ	ST	27.35	2.349	.000	*
		YQ	12.38	2.658	.000	*
		DQ	5.13	2.361	.134	
L2	ST	YQ	-29.86	2.101	.000	*
		DQ	-36.91	1.857	.000	*
	YQ	DQ	-7.05	2.111	.005	*
	WQ	ST	8.40	1.892	.000	*
		YQ	-21.46	2.141	.000	*
		DQ	-28.51	1.902	.000	*

2 Scaling of nuclear L1, H and L2

2.1 MANOVA results (significant effect marked with *)

MANOVA results: scaling of nuclear L1, H and L2							
Independent Variable	Dependent Variable	Sum of squares	df	Mean Square	F	Sig.	
SType	L1	67980.44	3	22660.15	156.674	0.000	*
	H	93287.00	3	31095.67	185.558	0.000	*
	L2	17603.71	3	5867.90	20.155	0.000	*
Tail	L1	2.04	1	2.04	0.014	0.906	
	H	14.34	1	14.34	0.086	0.770	
	L2	38.24	1	38.24	0.131	0.717	
Between	L1	490.82	5	98.16	0.679	0.640	
	H	722.53	5	144.51	0.862	0.507	
	L2	811.19	5	162.24	0.557	0.733	
Preceding * Between	L1	641.38	3	213.80	1.478	0.221	
	H	556.53	3	185.51	1.107	0.347	
	L2	585.66	3	195.22	0.671	0.571	
Preceding * SType	L1	1870.20	13	143.86	0.995	0.457	
	H	2991.48	13	230.11	1.373	0.172	
	L2	2752.24	13	211.71	0.727	0.736	
Between * SType	L1	462.17	3	154.06	1.065	0.364	
	H	304.31	3	101.44	0.605	0.612	
	L2	276.78	3	92.26	0.317	0.813	
Preceding * Between * Stype	L1	481.93	3	160.64	1.111	0.345	
	H	929.94	3	309.98	1.85	0.138	
	L2	360.01	3	120.00	0.412	0.744	
Error	L1	39774.05	275	144.63			
	H	46084.29	275	167.58			
	L2	80062.99	275	291.14			
Total	L1	546787.59	308				
	H	908946.91	308				
	L2	308669.46	308				

2.2 Descriptive statistics and pairwise comparisons for significant effect SENTENCE TYPE

Mean and standard error based on SENTENCE TYPE			
Dependent Variable	Dependent Variable	Dependent Variable	Dependent Variable
L1	ST	17.661	1.428
	YQ	51.33	2.256
	WQ	23.35	1.53
	DQ	59.02	1.471
H	ST	25.699	1.537
	YQ	63.775	2.428
	WQ	33.32	1.647
	DQ	75.586	1.583
L2	ST	18.357	2.026
	YQ	33.424	3.2
	WQ	15.933	2.171
	DQ	38.535	2.087

Tukey HSD Pairwise comparison for SENTENCE TYPE						
Dependent Variable	Stype	Stype	Mean Difference	Std. Error	Sig.	
L1	ST	YQ	-34.49	2.063	0.000	*
		DQ	-42.22	1.829	0.000	*
	YQ	DQ	-7.72	2.086	0.001	*
	WQ	ST	6.24	1.853	0.005	*
		YQ	-28.25	2.107	0.000	*
		DQ	-35.97	1.879	0.000	*
H	ST	YQ	-40.1	2.22	0.000	*
		DQ	-50.73	1.969	0.000	*
	YQ	DQ	-10.62	2.245	0.000	*
	WQ	ST	8.04	1.994	0.000	*
		YQ	-32.06	2.268	0.000	*
		DQ	-42.68	2.022	0.000	*
L2	ST	YQ	-14.96	2.927	0.000	*
		DQ	-18.64	2.596	0.000	*
	YQ	DQ	-3.68	2.96	0.599	
	WQ	ST	-2.5	2.629	0.777	
		YQ	-17.46	2.989	0.000	*
		DQ	-21.14	2.666	0.000	*

3 Comparison between reading and map task for linear Hz measure

ANOVA Results: Female Statements- Hz							
Independent Variable	Dependent Variable	Sum of squares	df	Mean Square	F	Sig.	
Read_Map	L1_Hz	1825.825	1	1825.825	2.372	0.129	
	H_Hz	4042.302	1	4042.302	3.365	0.071	
	L2_Hz	4595.6	1	4595.6	8.281	0.005	*
Error	L1_Hz	48486.268	63	769.623			
	H_Hz	75683.422	63	1201.324			
	L2_Hz	34962.87	63	554.966			
Total	L1_Hz	3033378.088	65				
	H_Hz	3780480.029	65				
	L2_Hz	2518481.85	65				

ANOVA Results: Male Statements- Hz							
Independent Variable	Dependent Variable	Sum of squares	df	Mean Square	F	Sig.	
Read_Map	L1_Hz	2073.32	1	2073.32	2.92	0.089	
	H_Hz	8099.168	1	8099.168	5.137	0.025	*
	L2_Hz	776.935	1	776.935	2.571	0.111	
Error	L1_Hz	110041.02	155	709.942			
	H_Hz	244390.39	155	1576.712			
	L2_Hz	46830.76	155	302.134			
Total	L1_Hz	2201629.468	157				
	H_Hz	3170418.986	157				
	L2_Hz	1866956.295	157				

ANOVA Results: Female wh-questions- Hz							
Independent Variable	Dependent Variable	Sum of squares	df	Mean Square	F	Sig.	
Read_Map	L1_Hz	4027.5	1	4027.5	1.037	0.313	
	H_Hz	6958.57	1	6958.57	1.365	0.248	
	L2_Hz	1309.964	1	1309.964	1.402	0.242	
Error	L1_Hz	201875.309	52	3882.217			
	H_Hz	265119.012	52	5098.443			
	L2_Hz	48570.939	52	934.057			
Total	L1_Hz	3618054.49	54				
	H_Hz	4513000.111	54				
	L2_Hz	2021025.273	54				

ANOVA Results: Male wh-questions- Hz							
Independent Variable	Dependent Variable	Sum of squares	df	Mean Square	F	Sig.	
Read_Map	L1_Hz	11120.647	1	11120.65	3.37	0.069	
	H_Hz	18322.794	1	18322.79	3.45	0.066	
	L2_Hz	251.243	1	251.24	0.35	0.555	
Error	L1_Hz	372462.715	113	3296.13			
	H_Hz	599796.364	113	5307.93			
	L2_Hz	81011.731	113	716.92			
Total	L1_Hz	3047447.557	115				
	H_Hz	4380061.42	115				
	L2_Hz	1700565.488	115				

ANOVA Results: Female yes-no questions- Hz							
Independent Variable	Dependent Variable	Sum of squares	df	Mean Square	F	Sig.	
Read_Map	L1_Hz	15303.368	1	15303.368	8.11	0.007	*
	H_Hz	24810.231	1	24810.231	6.977	0.012	*
	L2_Hz	2151.634	1	2151.634	0.558	0.459	
Error	L1_Hz	77361.888	41	1886.875			
	H_Hz	145798.48	41	3556.06			
	L2_Hz	158076.966	41	3855.536			
Total	L1_Hz	3478684.459	43				
	H_Hz	4474258.685	43				
	L2_Hz	2953295.41	43				

ANOVA Results: Male yes-no questions- Hz							
Independent Variable	Dependent Variable	Sum of squares	df	Mean Square	F	Sig.	
Read_Map	L1_Hz	8345.91	1	8345.91	2.938	0.090	
	H_Hz	10333.719	1	10333.719	2.571	0.112	
	L2_Hz	1939.602	1	1939.602	1.035	0.312	
Error	L1_Hz	247177.53	87	2841.121			
	H_Hz	349739.482	87	4019.994			
	L2_Hz	163105.792	87	1874.779			
Total	L1_Hz	2450421.405	89				
	H_Hz	3372072.385	89				
	L2_Hz	2018133.32	89				

Appendix E

Scaling comparison for reading and map task by speaker

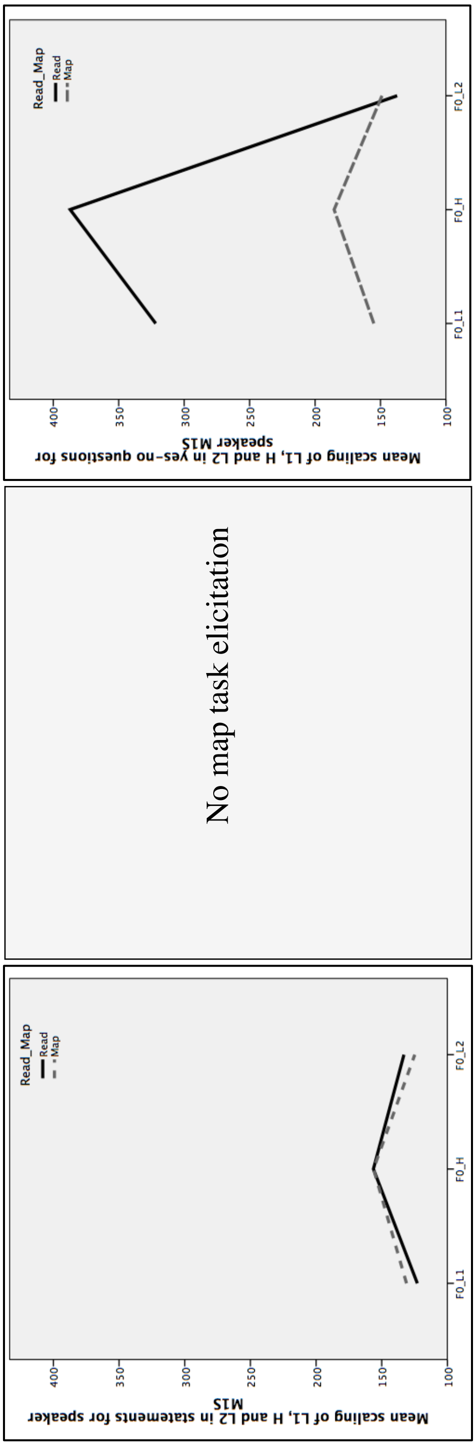


Figure A: Mean scaling of nuclear L1, H and L2 in statements (left) and yes-no questions (right) for speaker M1S (mean Hz)

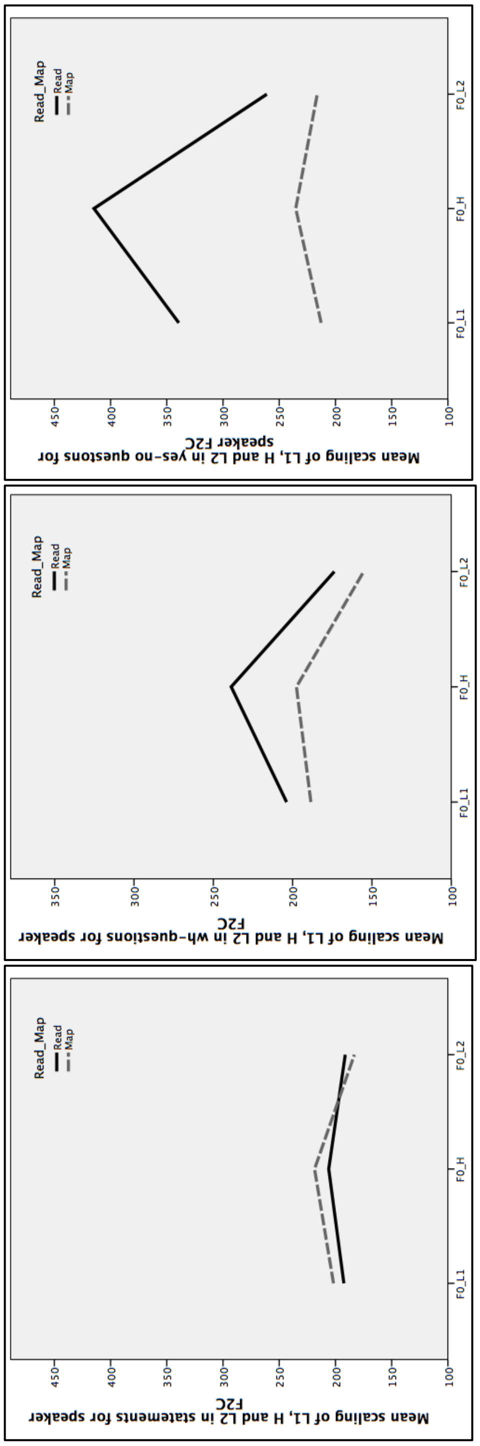


Figure B: Mean scaling of nuclear L1, H and L2 in statements (left) wh-questions (centre) and yes-no questions (right) for speaker F2C (mean Hz)

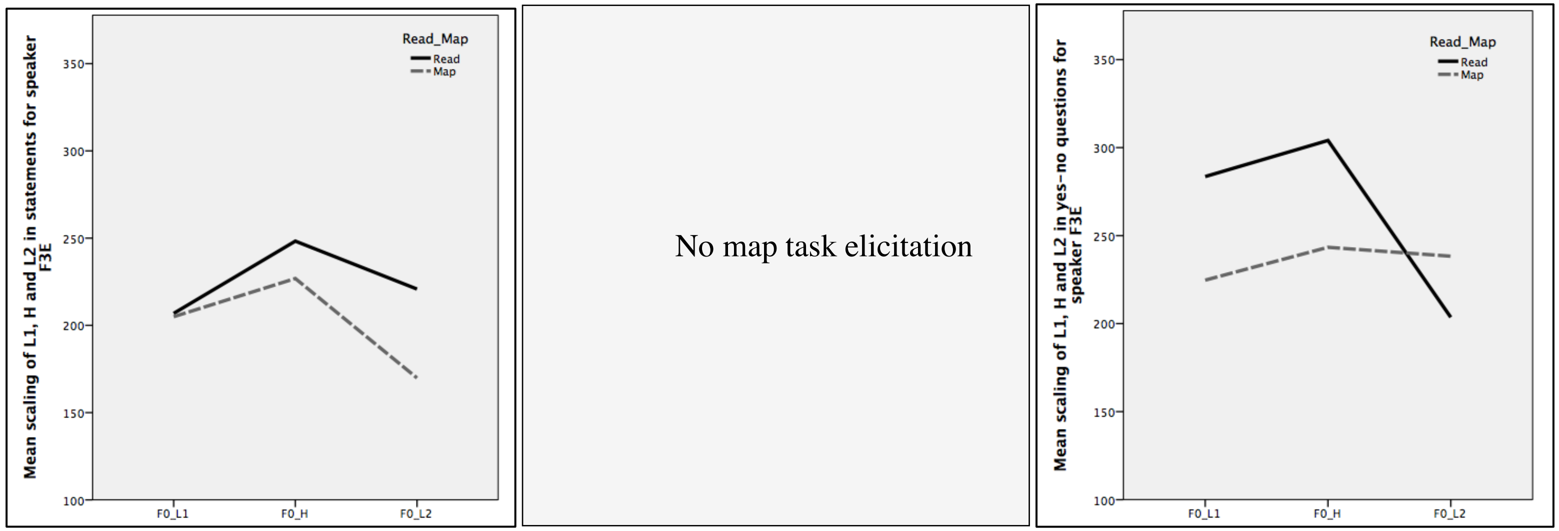


Figure C: Mean scaling of nuclear L1, H and L2 in statements (left) and wh-questions (right) for speaker F3E

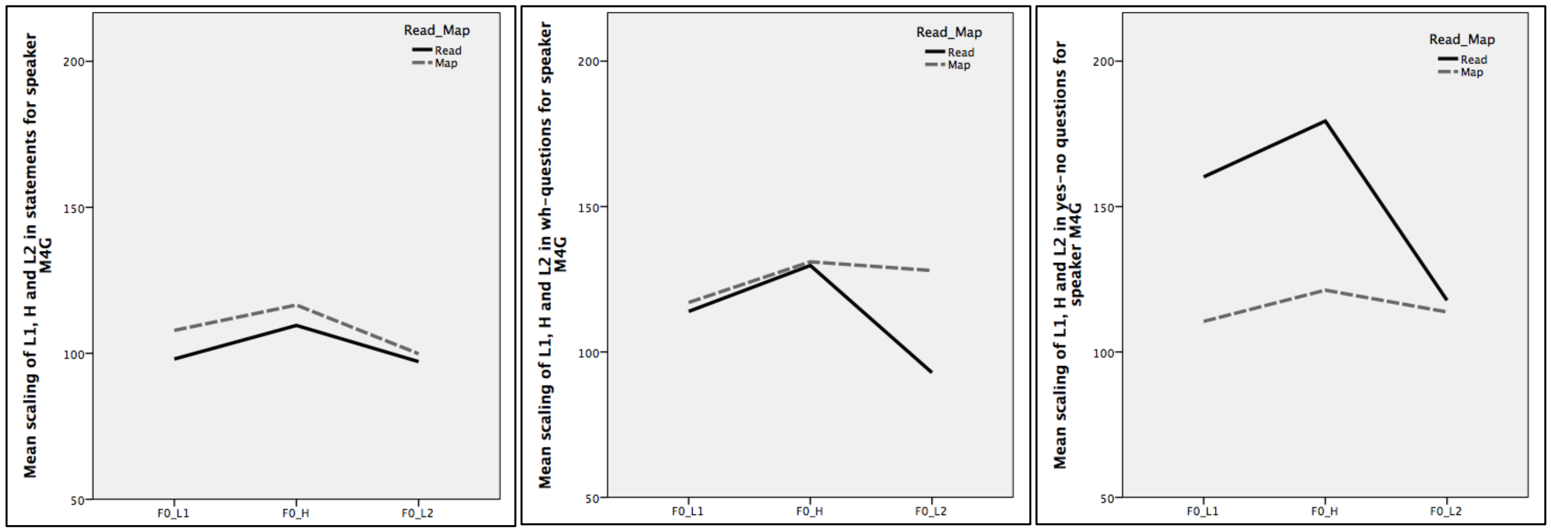


Figure D: Mean scaling of nuclear L1, H and L2 in statements (left), wh-questions (centre) and yes-no questions (right) for speaker M4G (mean Hz)

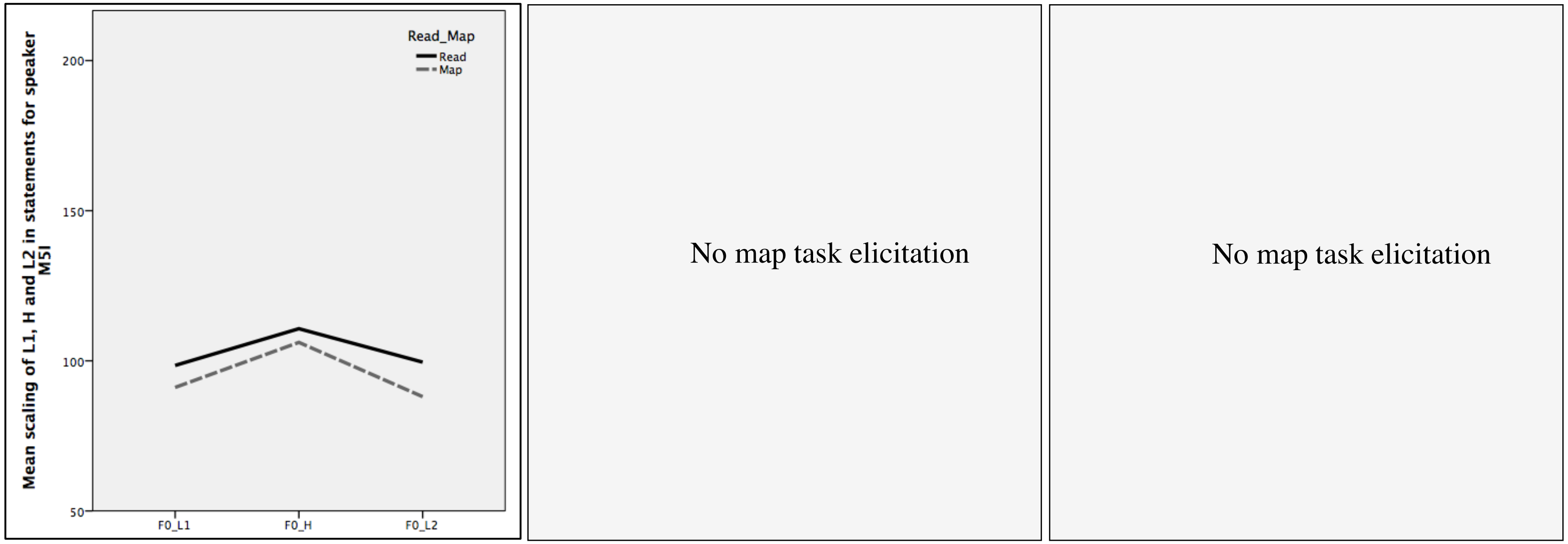


Figure E: Mean scaling of nuclear L1, H and L2 in statements (left) for speaker M5I (mean Hz)

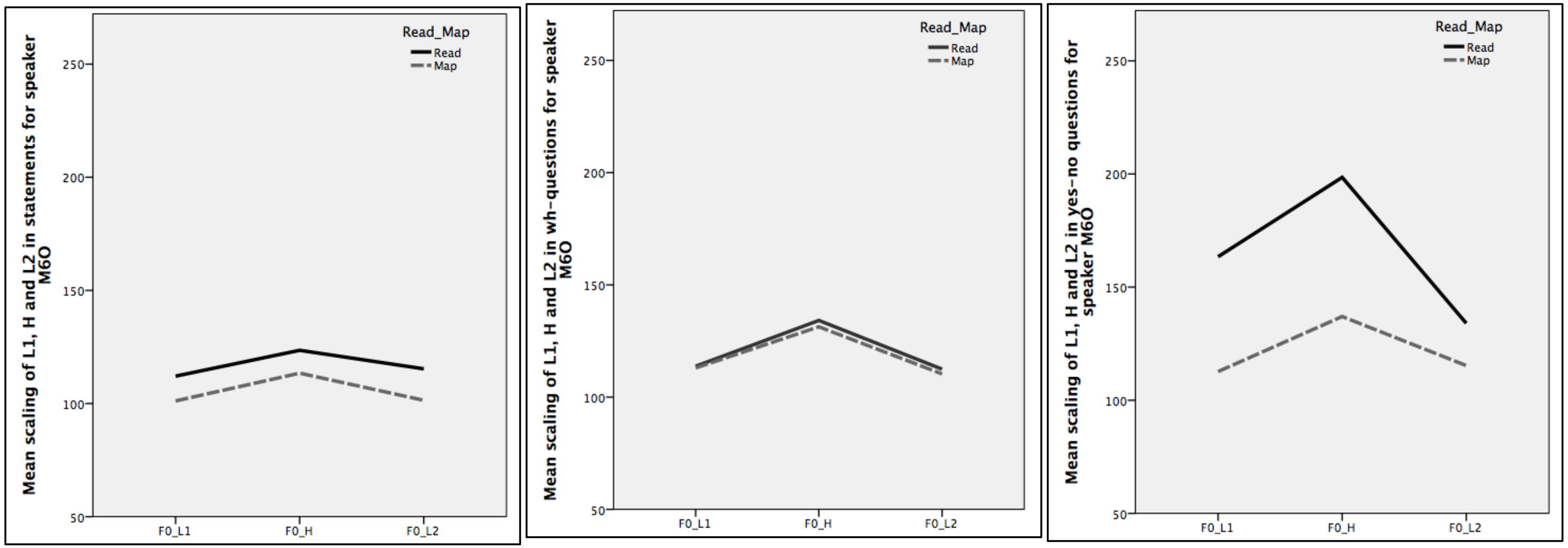


Figure F: Mean scaling of nuclear L1, H and L2 in statements (left), wh-questions (centre) and yes-no questions (right) for speaker M60 (mean Hz)

Appendix F

Statistical tests for Alignment Chapter

1 Prenuclear target alignment

1.1 MANOVA results (significant effect marked with *)

MANOVA results: alignment of prenuclear L1, H and L2							
Independent Variable	**Dependent Variable**	**Sum of squares**	**df**	**Mean Square**	**F**	**Sig.**	
SType	VtoH	22739.2	3	7579.7	5.3	0.001	*
	C1toH	29705.7	3	9901.9	7.6	0.000	*
	CtoL	31247.8	3	10415.9	5.4	0.001	*
	C1toL1	67896.2	3	22632.1	6.9	0.000	*
Between	VtoH	5788.0	5	1157.6	0.8	0.546	
	C1toH	51251.0	5	10250.2	7.8	0.000	*
	CtoL	10604.9	5	2121.0	1.1	0.361	
	C1toL1	111797.6	5	22359.5	6.8	0.000	*
Preceding	VtoH	8662.6	2	4331.3	3.0	0.051	
	C1toH	11268.0	2	5634.0	4.3	0.014	*
	CtoL	5718.7	2	2859.4	1.5	0.229	
	C1toL1	42071.8	2	21035.9	6.4	0.002	*
SType * Between	VtoH	13035.7	8	1629.5	1.1	0.340	
	C1toH	25864.1	8	3233.0	2.5	0.013	*
	CtoL	7910.8	8	988.9	0.5	0.847	
	C1toL1	27141.1	8	3392.6	1.0	0.410	
SType * Preceding	VtoH	28734.8	2	14367.4	10.0	0.000	*
	C1toH	6885.5	2	3442.7	2.6	0.074	
	CtoL	5926.2	2	2963.1	1.5	0.217	
	C1toL1	12697.7	2	6348.8	1.9	0.146	
Between * Preceding	VtoH	12145.1	3	4048.4	2.8	0.039	*
	C1toH	10366.3	3	3455.4	2.6	0.050	
	CtoL	10397.7	3	3465.9	1.8	0.148	
	C1toL1	18516.6	3	6172.2	1.9	0.133	
Error	VtoH	420913.5	293	1436.6			
	C1toH	384187.6	293	1311.2			
	CtoL	565051.5	293	1928.5			
	C1toL1	960800.2	293	3279.2			
Total	VtoH	1017322.4	324				
	C1toH	1503588.6	324				
	CtoL	790625.2	324				
	C1toL1	3968925.0	324				

1.2 Pairwise comparisons for SENTENCE TYPE

Tukey HSD Pairwise comparison for sentence type						
Dependent Variable	Stype	Stype	Mean Difference	Std. Error	Sig.	
VtoH	ST	YQ	-11.6	6.0	0.214	
		WQ	-9.1	5.9	0.413	
		DQ	-15.1	5.7	0.044	*
	YQ	ST	11.6	6.0	0.214	
		WQ	2.5	6.2	0.977	
		DQ	-3.5	6.1	0.940	
	WQ	ST	9.1	5.9	0.413	
		YQ	-2.5	6.2	0.977	
		DQ	-6.0	6.0	0.745	
	DQ	ST	15.1	5.7	0.044	
		YQ	3.5	6.1	0.940	
		WQ	6.0	6.0	0.745	
C1toH	ST	YQ	-14.0	5.7	0.071	
		WQ	-10.0	5.6	0.289	
		DQ	-27.4	5.5	0.000	*
	YQ	ST	14.0	5.7	0.071	
		WQ	4.0	5.9	0.904	
		DQ	-13.4	5.8	0.100	
	WQ	ST	10.0	5.6	0.289	
		YQ	-4.0	5.9	0.904	
		DQ	-17.4	5.7	0.013	*
	DQ	ST	27.4	5.5	0.000	*
		YQ	13.4	5.8	0.100	
		WQ	17.4	5.7	0.013	
CtoL	ST	YQ	-13.9	6.9	0.192	
		WQ	20.6	6.8	0.014	*
		DQ	-13.8	6.6	0.163	
	YQ	ST	13.9	6.9	0.192	
		WQ	34.5	7.2	0.000	*
		DQ	0.1	7.0	1.000	
	WQ	ST	-20.6	6.8	0.014	*
		YQ	-34.5	7.2	0.000	*
		DQ	-34.4	6.9	0.000	*
	DQ	ST	13.8	6.6	0.163	
		YQ	-0.1	7.0	1.000	
		WQ	34.4	6.9	0.000	*
C1toL1	ST	YQ	16.0	9.1	0.291	
		WQ	-40.1	8.9	0.000	*
		DQ	27.3	8.7	0.010	*
	YQ	ST	-16.0	9.1	0.291	
		WQ	-56.1	9.4	0.000	*

		DQ	11.2	9.2	0.611	
	WQ	ST	40.1	8.9	0.000	*
		YQ	56.1	9.4	0.000	*
		DQ	67.4	9.0	0.000	*
	DQ	ST	-27.3	8.7	0.010	*
		YQ	-11.2	9.2	0.611	
		WQ	-67.4	9.0	0.000	*

1.3 Pairwise comparisons for BETWEEN

Tukey HSD Pairwise comparison for between						
Dependent Variable	Between	Between	Mean Difference	Std. Error	Sig.	
C1toH	0	1	38.2	11.7	0.016	*
		2	14.3	11.4	0.813	
		3	11.9	12.0	0.922	
		4	14.6	12.6	0.854	
		5	-1.2	12.2	1.000	
	1	0	-38.2	11.7	0.016	*
		2	-23.9	5.4	0.000	*
		3	-26.3	6.6	0.001	*
		4	-23.6	7.5	0.023	*
		5	-39.4	7.0	0.000	*
	2	0	-14.3	11.4	0.813	
		1	23.9	5.4	0.000	*
		3	-2.4	6.1	0.999	
		4	0.3	7.1	1.000	
		5	-15.5	6.5	0.167	
	3	0	-11.9	12.0	0.922	
		1	26.3	6.6	0.001	*
		2	2.4	6.1	0.999	
		4	2.7	8.0	0.999	
		5	-13.0	7.5	0.507	
	4	0	-14.6	12.6	0.854	
		1	23.6	7.5	0.023	*
		2	-0.3	7.1	1.000	
		3	-2.7	8.0	0.999	
		5	-15.8	8.3	0.405	
C1toL1	0	1	-42.6	18.5	0.197	
		2	-63.1	18.1	0.007	*
		3	-78.4	19.0	0.001	*
		4	-85.3	19.9	0.000	*
		5	-84.7	19.3	0.000	*

	1	0	42.6	18.5	0.197	
		2	-20.5	8.6	0.167	
		3	-35.8	10.5	0.009	*
		4	-42.7	11.9	0.005	*
		5	-42.0	11.0	0.002	*
	2	0	63.1	18.1	0.007	*
		1	20.5	8.6	0.167	
		3	-15.3	9.7	0.610	
		4	-22.2	11.2	0.357	
		5	-21.5	10.3	0.292	
	3	0	78.4	19.0	0.001	*
		1	35.8	10.5	0.009	*
		2	15.3	9.7	0.610	
		4	-6.9	12.7	0.994	
		5	-6.2	11.9	0.995	
	4	0	85.3	19.9	0.000	*
		1	42.7	11.9	0.005	*
		2	22.2	11.2	0.357	
		3	6.9	12.7	0.994	
		5	0.6	13.1	1.000	

1.4 Pairwise comparisons for PRECEDING

Tukey HSD Pairwise comparison for preceding						
Dependent Variable	**Preceding**	**Preceding**	**Mean Difference**	**Std. Error**	**Sig.**	
C1toH	1	2	-4.9	4.4	0.512	
		3	16.5	5.8	0.012	*
	2	1	4.9	4.4	0.512	
		3	21.4	5.9	0.001	*
	3	1	-16.5	5.8	0.012	*
		2	-21.4	5.9	0.001	*
C1toL1	1	2	-29.6	7.0	0.000	*
		3	-28.2	9.1	0.006	*
	2	1	29.6	7.0	0.000	*
		3	1.4	9.3	0.988	
	3	1	28.2	9.1	0.006	*
		2	-1.4	9.3	0.988	

1.5 One way ANOVAs for significant interactions in MANOVA in 1.1

Interaction C1 to H: stype x between (statements)					
ANOVA	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	40501.1	5	8100.2	7.2	0.000
Within Groups	95104.0	85	1118.9		
Total	135605.1	90			

Interaction C1 to H: stype x between (yes-no questions)					
ANOVA	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	22403.7	5	4480.7	3.6	0.005
Within Groups	97858.2	79	1238.7		
Total	120261.9	84			

Interaction C1 to H: stype x between (wh-questions)					
ANOVA	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	24940.4	4	6235.1	2.9	0.028
Within Groups	166757.8	77	2165.7		
Total	191698.2	81			

Interaction C1 to H: stype x between (declarative questions)					
ANOVA	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	15457.4	5	3091.5	2.4	0.044
Within Groups	101593.2	79	1286.0		
Total	117050.6	84			

Interaction V to H: preceding x stype (statements)					
ANOVA	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	17587.8	2	8793.9	8.1	0.001
Within Groups	96086.4	88	1091.9		
Total	113674.2	90			

Interaction V to H: preceding x stype (yes-no questions)					
ANOVA	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	15421.0	2	7710.5	5.2	0.008
Within Groups	124213.6	83	1496.5		
Total	139634.5	85			

Interaction V to H: preceding x stype (wh-questions)					
ANOVA	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	9071.3	1	9071.3	4.2	0.043
Within Groups	172088.4	80	2151.1		
Total	181159.7	81			

Interaction V to H: preceding x stype (declarative questions)					
ANOVA	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	24503.0	2	12251.5	9.8	0.000
Within Groups	102837.8	82	1254.1		

Total	127340.8	84			

Interaction V to H: preceding x between (preceding = 1)					
ANOVA	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	15210.2	5	3042.0	2.0	0.080
Within Groups	214599.1	142	1511.3		
Total	229809.2	147			

Interaction V to H: preceding x between (preceding = 2)					
ANOVA	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	6207.5	5	1241.5	0.9	0.495
Within Groups	191498.8	136	1408.1		
Total	197706.3	141			

Interaction V to H: preceding x between (preceding = 3)					
ANOVA	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	2787.6	2	1393.8	0.6	0.569
Within Groups	124490.5	51	2441.0		
Total	127278.1	53			

1.6 Post-hoc results for significant interactions in Section 1.5

Testing Interaction: prenuclear C1 to H (statements)				
Between	Between	Mean Difference	Std. Error	Sig.
0	1	63.0	20.9	0.038
	2	26.9	20.1	0.762
	3	42.1	21.6	0.379
	4	13.6	23.7	0.992
	5	0.8	20.9	1.000
1	0	-63.0	20.9	0.038
	2	-36.1	9.7	0.005
	3	-20.9	12.5	0.549
	4	-49.4	15.8	0.028
	5	-62.2	11.3	0.000
2	0	-26.9	20.1	0.762
	1	36.1	9.7	0.005
	3	15.2	11.2	0.753
	4	-13.3	14.8	0.945
	5	-26.1	9.9	0.098
3	0	-42.1	21.6	0.379
	1	20.9	12.5	0.549
	2	-15.2	11.2	0.753
	4	-28.5	16.7	0.533
	5	-41.3	12.6	0.019
4	0	-13.6	23.7	0.992
	1	49.4	15.8	0.028
	2	13.3	14.8	0.945
	3	28.5	16.7	0.533
	5	-12.8	15.9	0.966

Testing Interaction: prenuclear C1 to H (yes-no questions)				
Between	Between	Mean Difference	Std. Error	Sig.
0	1	10.0	17.5	0.993
	2	3.4	17.1	1.000
	3	-8.6	19.0	0.998
	4	-28.1	19.0	0.678
	5	-36.1	19.3	0.426
1	0	-10.0	17.5	0.993
	2	-6.6	10.2	0.987
	3	-18.5	13.1	0.718
	4	-38.1	13.1	0.052
	5	-46.1	13.5	0.013
2	0	-3.4	17.1	1.000
	1	6.6	10.2	0.987

	3	-12.0	12.6	0.932
	4	-31.5	12.6	0.136
	5	-39.5	13.0	0.037
3	0	8.6	19.0	0.998
	1	18.5	13.1	0.718
	2	12.0	12.6	0.932
	4	-19.5	15.0	0.784
	5	-27.5	15.4	0.477
4	0	28.1	19.0	0.678
	1	38.1	13.1	0.052
	2	31.5	12.6	0.136
	3	19.5	15.0	0.784
	5	-8.0	15.4	0.995

Testing Interaction: prenuclear C1 to H (wh-questions)				
Between	Between	Mean Difference	Std. Error	Sig.
1	2	-41.6	15.5	0.066
	3	-38.6	14.6	0.073
	4	-15.5	15.7	0.861
	5	-48.0	21.9	0.196
2	1	41.6	15.5	0.066
	3	3.0	14.6	1.000
	4	26.1	15.7	0.467
	5	-6.4	21.9	0.998
3	1	38.6	14.6	0.073
	2	-3.0	14.6	1.000
	4	23.1	14.9	0.532
	5	-9.3	21.3	0.992
4	1	15.5	15.7	0.861
	2	-26.1	15.7	0.467
	3	-23.1	14.9	0.532
	5	-32.5	22.1	0.586

Testing Interaction: prenuclear C1 to H (declarative questions)				
Between	Between	Mean Difference	Std. Error	Sig.
0	1	46.9	22.6	0.309
	2	28.6	21.6	0.770
	3	2.3	23.4	1.000
	4	22.3	26.2	0.957
	5	27.9	22.6	0.818
1	0	-46.9	22.6	0.309
	2	-18.3	10.9	0.549
	3	-44.6	14.0	0.025
	4	-24.6	18.4	0.762
	5	-19.0	12.7	0.665

2	0	-28.6	21.6	0.770
	1	18.3	10.9	0.549
	3	-26.4	12.4	0.288
	4	-6.4	17.2	0.999
	5	-0.8	10.9	1.000
3	0	-2.3	23.4	1.000
	1	44.6	14.0	0.025
	2	26.4	12.4	0.288
	4	20.0	19.3	0.905
	5	25.6	14.0	0.457
4	0	-22.3	26.2	0.957
	1	24.6	18.4	0.762
	2	6.4	17.2	0.999
	3	-20.0	19.3	0.905
	5	5.6	18.4	1.000

Testing Interaction: V to H (statements)				
Preceding	Preceding	Mean Difference	Std. Error	Sig.
1	2	-10.5	9.0	0.480
	3	37.1	10.4	0.002
2	1	10.5	9.0	0.480
	3	47.6	12.5	0.001

Testing Interaction: V to H (yes-no questions)				
Preceding	Preceding	Mean Difference	Std. Error	Sig.
1	2	-0.7	9.1	0.996
	3	-73.5	23.5	0.007
2	1	0.7	9.1	0.996
	3	-72.7	22.9	0.006

Testing Interaction: prenuclear V to H (declarative questions)				
1	2	26.6	10.0	0.025
	3	47.7	12.1	0.000
2	1	-26.6	10.0	0.025
	3	21.1	14.3	0.306

Testing Interaction: prenuclear V to H (preceding = 1)				
Between	Between	Mean Difference	Std. Error	Sig.
1	0	-5.1	17.7	1.000
	2	-9.0	9.1	0.920
	3	-29.4	10.8	0.077
	4	-9.1	14.2	0.988
	5	-35.5	21.0	0.541
2	0	4.0	16.5	1.000

	1	9.0	9.1	0.920
	3	-20.4	8.6	0.174
	4	0.0	12.6	1.000
	5	-26.4	19.9	0.771
3	0	24.4	17.5	0.731
	1	29.4	10.8	0.077
	2	20.4	8.6	0.174
	4	20.3	13.8	0.683
	5	-6.0	20.8	1.000
4	0	4.0	19.7	1.000
	1	9.1	14.2	0.988
	2	0.0	12.6	1.000
	3	-20.3	13.8	0.683
	5	-26.4	22.7	0.854
5	0	30.4	25.1	0.831
	1	35.5	21.0	0.541
	2	26.4	19.9	0.771
	3	6.0	20.8	1.000
	4	26.4	22.7	0.854

2 Nuclear Target alignment

2.1 MANOVA results (significant effect marked with *)

MANOVA results: alignment of nuclear L1, H and L2							
Independent Variable	**Dependent Variable**	**Sum of squares**	**df**	**Mean Square**	**F**	**Sig.**	
SType	VtoH	6979.9	3	2326.6	1.4	0.233	
	C1toH	31241.2	3	10413.7	3.9	0.009	*
	CtoL	4963.2	3	1654.4	0.9	0.421	
	C1toL1	5497.1	3	1832.4	0.7	0.577	
Between	VtoH	28016.2	5	5603.2	3.5	0.005	*
	C1toH	21229.7	5	4245.9	1.6	0.162	
	CtoL	21155.7	5	4231.1	2.4	0.037	*
	C1toL1	30249.4	5	6049.9	2.2	0.057	
Tail	VtoH	57531.7	1	57531.7	35.5	0.000	*
	C1toH	96472.0	1	96472.0	36.2	0.000	*
	CtoL	4758.0	1	4758.0	2.7	0.101	
	C1toL1	211598.7	1	211598.7	76.3	0.000	*
SType * Between	VtoH	34374.8	13	2644.2	1.6	0.076	
	C1toH	55414.7	13	4262.7	1.6	0.084	
	CtoL	40771.1	13	3136.2	1.8	0.046	
	C1toL1	24467.3	13	1882.1	0.7	0.784	
SType * Tail	VtoH	1125.4	3	375.1	0.2	0.874	
	C1toH	8845.0	3	2948.3	1.1	0.346	
	CtoL	717.4	3	239.1	0.1	0.939	
	C1toL1	9436.9	3	3145.7	1.1	0.336	
Between * Tail	VtoH	15959.1	3	5319.7	3.3	0.021	*
	C1toH	60236.7	3	20078.9	7.5	0.000	*
	CtoL	6485.1	3	2161.7	1.2	0.300	
	C1toL1	38640.1	3	12880.0	4.6	0.003	*
SType * Between * Tail	VtoH	2632.6	3	877.5	0.5	0.654	
	C1toH	4777.2	3	1592.4	0.6	0.617	
	CtoL	1167.3	3	389.1	0.2	0.882	
	C1toL1	847.5	3	282.5	0.1	0.959	
Error	VtoH	443957.5	274	1620.3			
	C1toH	729463.7	274	2662.3			
	CtoL	481973.6	274	1759.0			
	C1toL1	760272.9	274	2774.7			
Total	VtoH	933733.0	307				
	C1toH	2715249.5	307				
	CtoL	597065.8	307				
	C1toL1	2244587.0	307				

2.2 Pairwise comparisons for SENTENCE TYPE

Tukey HSD Pairwise comparison for sentence type						
Dependent Variable	**Stype**	**Stype**	**Mean Difference**	**Std. Error**	**Sig.**	
C1toH	ST	YQ	12.8	8.2	0.402	
		WQ	-1.7	8.3	0.997	
		DQ	14.1	8.2	0.315	
	YQ	ST	-12.8	8.2	0.402	
		WQ	-14.5	8.5	0.320	
		DQ	1.3	8.3	0.999	
	WQ	ST	1.7	8.3	0.997	
		YQ	14.5	8.5	0.320	
		DQ	15.8	8.5	0.246	

2.3 Pairwise comparisons for BETWEEN

Tukey HSD Pairwise comparison for between						
Dependent Variable	**Between**	**Between**	**Mean Difference**	**Std. Error**	**Sig.**	
VtoH	0	1	18.5	12.0	0.636	
		2	18.7	11.5	0.579	
		3	11.4	12.1	0.934	
		4	11.1	12.5	0.949	
		5	29.5	12.6	0.182	
	1	0	-18.5	12.0	0.636	
		2	0.2	6.6	1.000	
		3	-7.1	7.6	0.936	
		4	-7.4	8.3	0.947	
		5	10.9	8.4	0.788	
	2	0	-18.7	11.5	0.579	
		1	-0.2	6.6	1.000	
		3	-7.3	6.7	0.887	
		4	-7.6	7.5	0.913	
		5	10.8	7.6	0.722	
	3	0	-11.4	12.1	0.934	
		1	7.1	7.6	0.936	
		2	7.3	6.7	0.887	
		4	-0.3	8.4	1.000	
		5	18.1	8.5	0.277	
	4	0	-11.1	12.5	0.949	
		1	7.4	8.3	0.947	
		2	7.6	7.5	0.913	
		3	0.3	8.4	1.000	
		5	18.4	9.1	0.337	

CtoL	0	1	11.5	12.5	0.941	
		2	6.3	11.9	0.995	
		3	26.7	12.6	0.278	
		4	11.1	13.0	0.958	
		5	10.7	13.1	0.964	
	1	0	-11.5	12.5	0.941	
		2	-5.2	6.9	0.976	
		3	15.2	7.9	0.396	
		4	-0.4	8.7	1.000	
		5	-0.8	8.8	1.000	
	2	0	-6.3	11.9	0.995	
		1	5.2	6.9	0.976	
		3	20.3	7.0	0.045	
		4	4.8	7.8	0.990	
		5	4.4	8.0	0.994	
	3	0	-26.7	12.6	0.278	
		1	-15.2	7.9	0.396	
		2	-20.3	7.0	0.045	
		4	-15.6	8.7	0.475	
		5	-15.9	8.8	0.468	
	4	0	-11.1	13.0	0.958	
		1	0.4	8.7	1.000	
		2	-4.8	7.8	0.990	
		3	15.6	8.7	0.475	
		5	-0.3	9.5	1.000	

2.4 Pairwise comparisons for TAIL

Note as there are only 2 categories in tail, TUKEY's HSD could not be calculated: 0*1 is significantly different at the level reported in the overall MANOVA table in Section 2.1.

2.5 One way ANOVAs for significant interactions in MANOVA in 2.1

Interaction V to H: between x tail (0 tail)					
ANOVA	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	21433.9	5	4286.8	3.389	0.006
Within Groups	202367.1	160	1264.8		
Total	223801.1	165			

Interaction V to H: between x tail (1 tail)					
ANOVA	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	7987.4	4	1996.9	0.941	0.442
Within Groups	350047.6	165	2121.5		
Total	358035.0	169			

Interaction C1 to H: between x tail (0 tail)					
ANOVA	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	24008.6	5	4801.7	1.7	0.138
Within Groups	406698.6	144	2824.3		
Total	430707.2	149			

Interaction C1 to H: between x tail (1 tail)					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	61500.0	4	15375.0	5.946	0.000
Within Groups	418863.9	162	2585.6		
Total	480363.9	166			

Interaction C1 to L1: between x tail (0 tail)					
ANOVA	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	26608.3	5	5321.7	2.319	0.046
Within Groups	330440.3	144	2294.7		
Total	357048.6	149			

Interaction C1 to L1: between x tail (1 tail)					
ANOVA	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	62246.6	4	15561.7	5.271	0.001
Within Groups	478268.3	162	2952.3		
Total	540514.9	166			

2.6 Post-hoc results for significant interactions in Section 2.5

Testing Interaction: nuclear V to H (0 tail)				
Between	Between	Mean Difference	Std. Error	Sig.
0	1	32.3	10.8	0.037
	2	34.5	10.8	0.021
	3	41.2	13.0	0.022
	4	47.9	14.3	0.013
	5	21.5	11.6	0.432
1	0	-32.3	10.8	0.037
	2	2.2	7.3	1.000
	3	8.9	10.3	0.954
	4	15.6	11.9	0.779
	5	-10.8	8.4	0.790
2	0	-34.5	10.8	0.021
	1	-2.2	7.3	1.000
	3	6.7	10.3	0.986
	4	13.4	11.9	0.870
	5	-13.0	8.4	0.631
3	0	-41.2	13.0	0.022
	1	-8.9	10.3	0.954
	2	-6.7	10.3	0.986
	4	6.7	13.9	0.997
	5	-19.7	11.1	0.482
4	0	-47.9	14.3	0.013
	1	-15.6	11.9	0.779
	2	-13.4	11.9	0.870
	3	-6.7	13.9	0.997
	5	-26.4	12.6	0.295
5	0	-21.5	11.6	0.432
	1	10.8	8.4	0.790
	2	13.0	8.4	0.631
	3	19.7	11.1	0.482
	4	26.4	12.6	0.295

Testing Interaction: nuclear C1 to H (1 tail)				
Between	Between	Mean Difference	Std. Error	Sig.
1	2	-32.8	13.4	0.107
	3	-57.6	14.2	0.001
	4	-61.0	15.0	0.001
	5	-27.2	16.7	0.482
2	1	32.8	13.4	0.107
	3	-24.8	10.3	0.122
	4	-28.2	11.5	0.106

	5	5.6	13.6	0.994
3	1	57.6	14.2	0.001
	2	24.8	10.3	0.122
	4	-3.4	12.4	0.999
	5	30.3	14.4	0.224
4	1	61.0	15.0	0.001
	2	28.2	11.5	0.106
	3	3.4	12.4	0.999
	5	33.7	15.3	0.181
5	1	27.2	16.7	0.482
	2	-5.6	13.6	0.994
	3	-30.3	14.4	0.224
	4	-33.7	15.3	0.181

Testing Interaction: nuclear C1 to L1 (1 tail)				
Between	Between	Mean Difference	Std. Error	Sig.
1	2	-32.4	14.3	0.160
	3	-64.7	15.1	0.000
	4	-50.4	16.0	0.017
	5	-33.1	17.9	0.348
2	1	32.4	14.3	0.160
	3	-32.3	11.1	0.032
	4	-18.0	12.3	0.586
	5	-0.7	14.6	1.000
3	1	64.7	15.1	0.000
	2	32.3	11.1	0.032
	4	14.3	13.3	0.817
	5	31.6	15.4	0.247
4	1	50.4	16.0	0.017
	2	18.0	12.3	0.586
	3	-14.3	13.3	0.817
	5	17.3	16.3	0.826
5	1	33.1	17.9	0.348
	2	0.7	14.6	1.000
	3	-31.6	15.4	0.247
	4	-17.3	16.3	0.826

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