Early phonological development in children residing in Welsh-English communities: typical and atypical patterns

By

Rhonwen Lewis
December 2021

Director of Studies: Dr Robert Mayr

Supervisor: Dr Lalage Sanders

Adviser: Prof Enlli Môn Thomas

Thesis submitted to the School of Sport and Health Sciences, Cardiff Metropolitan University for the degree of Doctor of Philosophy

Abstract

The rate and nature of speech development in children is influenced by a range of biological and linguistic factors. Construction and mastery of the phonological system, or systems, is underpinned by implicit and explicit learning mechanisms with the structure and content of the language input received providing a basis for this process (Vihman and Croft, 2007). For children living in Wales, there is a lack of information available on the trajectory of early Welsh and English speech development. A small number of studies have reported on the speech development of Welsh-English bilingual children (Mayr, Howells and Lewis, 2015; Mayr, Jones and Mennen, 2014; Munro *et al.*, 2005). However, none of these have included data on children younger than 2;6 nor those who are not following the expected developmental trajectory.

The aim of this study was to investigate the trajectory of early speech development among children from a Welsh-English bilingual community in North Wales. Longitudinal data collected from six children were analysed in relation to the production of consonants and word shapes. Data collection took place at eight-week intervals, starting at 13 months and continuing until the end of the single-word stage, a duration of up to 18 months. Children from single- and dual-language homes were video recorded whilst interacting with a parent during play. Their vocalisations were identified, transcribed and evaluated in relation to the range and prevalence of the consonants and word-shapes they contained. Whole-word templates were identified which allowed for conclusions to be drawn in relation to the emergence of (a) phonological system(s) (Vihman, 2017).

The results revealed between- and within-child cross-linguistic similarity in the production of consonants across Welsh and English language environments. Ambient language influence was found, however, in the structural properties of the words targeted and the children's production attempts. Both lexicon and consonant inventory growth was seen over time, but close inspection of the data revealed that the speech development of one child was different to the others, and therefore labelled atypical. Research to date on atypical bilingual speech has been limited to those over 3;0. This study therefore provides the first systematic account of early atypical speech development in a bilingual child. For children experiencing societal bilingualism, establishing the developmental trajectory, as well as identifying the role of the ambient language, has far-reaching clinical and theoretical implications.

Acknowledgements

I would firstly like to thank the children who participated in the study and their parents for agreeing to take part, as without them the research would not have been possible. Thank you for making time for my multiple visits to your homes - it was a privilege to share those hours with you and your little ones. I would also like to acknowledge the Coleg Cymraeg Cenedlaethol for funding the research.

I would next like to thank my supervisory team, Dr Robert Mayr and Dr Lalage Sanders. You have been a consistent source of wisdom, encouragement and faith and I would like to express my sincere gratitude for all the time and effort you have given me over the course of my PhD studies. I would also like to thank Prof Enlli Môn Thomas for her input, particularly in the early stages of the project.

A big thank you also to the Speech and Language Therapy team at Cardiff Met who have supported me unequivocally to complete this thesis alongside my lecturer role. We have been on this journey together and I would not have got to this point without you.

As the path that I have taken to get here has been far from straightforward, it is difficult to find the words to truly express my gratitude to my friends and family for everything they have done. To my husband, Ian, you have helped me in so many ways to get here, and for that I am truly grateful. I would also like to thank my son, Macsen, for being so understanding over the past few months when I have needed to dedicate most of my free time to getting this thesis finished. Finally, a special thank you to my Mum for believing in me and helping me to find the grit and determination to get to the end.

Table of Contents

1 Introduction 1

2 Speech development in children 8

2.1 Introduction 8

2.2 Developing phonological knowledge through experience 9

2.3 Early speech development 13

2.3.1 Speech perception 13
2.3.2 Early vocalisations 15
2.3.3 Speech production in the single-word period 19
2.3.4 Emergence of a phonological system 24

2.4 Early speech development in the presence of two languages 27

2.4.1 Learning to speak two languages 28
2.4.2 Experiencing a bilingual environment 32
2.4.3 Emergence of a bilingual phonological system 37
2.4.4 Speech development in Welsh-English bilinguals 39

2.5 Assessing speech development and identification of atypicality 42

2.5.1 Measuring early segmental development 42
2.5.2 Whole-word measures 43
2.5.3 Comparing speech development in monolingual and bilingual children 44
2.5.4 Atypical speech development 46
2.5.5 Atypical speech development in bilinguals 48

2.6 The present study 51

3 Method 53

3.1 Introduction 53

3.2 The linguistic context 53

3.2.1 Northern Welsh 53
3.2.2 Northern Welsh English 55
3.2.3 Similarities and differences 58

3.3 Ethical considerations 59

3.4 Participants 60

3.5 Data collection 64

3.6 Data analysis 66

3.6.1 Data preparation and transcription 66
3.6.2 Categorisation of vocalisations 67
3.6.3 Consonant Analysis 70
3.6.4 Analysis of word shapes 71

4 The production of consonants in typical development 75

4.1 Introduction 75

4.2 Number of vocalisations 76

4.2.1 Categorisation of sessions according to word stage 78

4.3 Frequency of consonant production by place and manner 79

4.3.1 Manner of articulation: Between-child group comparison 81
4.3.2 Manner of articulation: Within-child comparison 84
4.3.3 Place of articulation: Between-child group comparison 86

4.3.4 Place of articulation: Within-child comparison 90
4.4 Preferred sounds 92
4.5 Rate of consonant development 97
4.5.1 Inventory size: All vocalisations 98
4.5.2 Inventory size: Words 100
4.5.3 Inventory complexity 101
4.6 Discussion 103
4.6.1 The role of the ambient language 105
4.6.2 Consonant production over time 106
4.6.3 Individual patterns 108
5 Production of early words in typical development 109
5.1 Introduction 109
5.2 A closer look at the words produced 110
5.2.1 Types and tokens produced over time 110
5.2.2 Word shape inventory for target words 111
5.2.3 Popular word shapes across each language environment 113
5.3 Syllable number 114
5.3.1 Degree of match to target according to word-stage 114
5.3.2 Word production attempts in different language environments: Between-child comparison 115
5.3.3 Word production attempts in different language environments: Within-child comparison 117
5.3.4 A focus on individual samples: Identification of templates 118
5.4 Onset patterns 124
5.4.1 Degree of match to target according to word-stage 124
5.4.2 Word production attempts in different language environments: Between-child comparison 125
5.4.3 Word production attempts in different language environments: Within-child comparison 126
5.4.4 A focus on individual samples: Identification of templates 127
5.5 Coda patterns 134
5.5.1 Degree of match to target according to word-stage 134
5.5.2 Word production attempts in different language environments: Between-child comparison 135
5.5.3 Word production attempts in different language environments: Within-child comparison 136
5.5.4 A focus on individual samples: Identification of templates 137
5.6 Intra-word variability 143
5.7 Discussion 145
5.7.1 The role of the ambient language 146
5.7.2 Word production over time 149
6 Consonants and early words production in atypical development: a case study 152
6.1 Introduction 152
6.2 Ages and stages 153
6.3 Consonant development 156
6.3.1 Frequency of consonant production by manner 156
6.3.2 Frequency of consonant production by place 158
6.4 Preferred sounds produced in all vocalisations 161
6.5 Rate of consonant development 164
6.5.1 Inventory size across all vocalisations 164
6.5.2 Size of inventory in words 166
6.5.3 Inventory complexity in words 167

6.6 A closer look at the vocalisations produced 168
6.6.1 Proportion of vocalisations identified as words 168
6.6.2 Type-token ratio for words 170
6.6.3 Target word types 170

6.7 Syllable number 172
6.7.1 Degree of match to target 172
6.7.2 Word production attempts in different language environments 173
6.7.3 Individual samples: Application of the templatic approach 174

6.8 Onset patterns 177
6.8.1 Degree of match to target 177
6.8.2 Word production attempts in different language environments 178
6.8.3 Individual samples: application of the templatic approach 179

6.9 Coda patterns 181
6.9.1 Degree of match to target 181
6.9.2 Word production attempts in different language environments 182
6.9.3 Individual samples: Application of the templatic approach 183

6.10 Intra-word variability 186

6.11 Discussion 188
6.11.1 Similarities 189
6.11.2 Differences 191

7 General discussion 195

7.1 Research question 1 – How do phonological systems emerge during the single-word period? (RQ1) 196

7.2 Research question 2 – What is the role of the ambient language in the production of consonants and early words? (RQ2) 202

7.3 Research question 3 – How does identifying the trajectory of speech development in the single word period support the examination of atypicality? (RQ3) 207

7.4 Clinical Implications 210

7.5 Limitations of the study 211

7.6 Future research 213

7.7 Conclusion 214

References 217

Appendix A (Chapter 3) 237

Appendix A1 - Detailed language input information 237

Appendix A2 – Schedule of sessions recorded and analysed 239

Appendix B (Chapter 4) 240

Appendix B1 – Word lists 240

Appendix B2 - Occurrence of manner of articulation categories for individual children 250

Appendix B3 - Occurrence of place of articulation categories for individual children 251

Appendix C (Chapter 5) 252

Appendix C1 - Individual Target Word Inventories 252

Appendix D (Chapter 6) *253*
Appendix D1 – Number of vocalisations produced in each session **253**
Appendix D2 – Type-token ratio calculation **254**

Word count (excluding tables): 60,985

List of tables

Table 2.1 Example of selected and adapted forms (Vihman et al.,1994) 25
Table 3.1 A representative consonant inventory of Northern Welsh (Hannahs, 2013) 54
Table 3.2 Vowel system of Northern Welsh (Mayr and Davies, 2011) 55
Table 3.3 A representative consonant inventory of Welsh English (Wells, 1982) 55
Table 3.4 Traditional rural Welsh English vowels (Penhallurick, 2008) 56
Table 3.5 Group and participant information, including summary of language use patterns. 63
Table 3.6 Word identification procedure (Vihman and McCune, 1994) 68
Table 3.7 Example of how the vocalisation categories were assigned, Beca, English environment, 1;5;19. 70
Table 3.8 Example of application of the templatic approach to CVCV word production attempts: 72
Table 3.9 Words with multiple attempts depicted in relation to calculation of the variability ratio 73
Table 4.1 Total number of vocalisations captured per 30-minute session along with number of vocalisations categorised as words 76
Table 4.2 Number of word types produced during each session, alongside the age of the child, with an indication of the word-stage category to which they belonged. 79
Table 4.3 Each child's production of approximants in all vocalisations and words, Welsh and English environments 84
Table 4.4 Each child's production of postvelar consonants in all vocalisations and in words, Welsh and English environments 89
Table 4.5 Each child's production of coronal consonants in all vocalisations and in words, Welsh and English environments 90
Table 4.6 Percentage occurrence of most frequently produced sounds in all vocalisations; Welsh environment 93
Table 4.7 Percentage occurrence of most frequently produced sounds in all vocalisations; English environment 94
Table 4.8 Percentage occurrence of preferred sounds in words; Welsh environment 95
Table 4.9 Percentage occurrence of preferred words in words; English environment 96
Table 4.10 Consonant inventories for vocalisations identified as words; Welsh environment 102
Table 4.11 Consonant inventories for vocalisations identified as words; English environment 103
Table 5.1 Number of word types and tokens produced by each child in each session, Welsh and English environments 111
Table 5.2 Number of attempts to produce various target types that matched the target in terms of syllable number: Word-stage category comparison 115
Table 5.3 Word production attempts adapted to CV through syllable omission, Welsh environment 120
Table 5.4 Word production attempts adapted to CV through syllable omission, English environment 121
Table 5.5 Word production attempts adapted to CVCV through syllable addition and omission, Welsh environment 122
Table 5.6 Word production attempts adapted to CVCV through syllable addition and omission, English environment 124
Table 5.7 Number of attempts to produce various target types that matched the target in terms of onset production: Word-stage category comparison, Welsh and English environments 125
Table 5.8 Word production attempts adapted to CVC through onset addition, Welsh environment 128
Table 5.9 Word production attempts adapted to CVCV and CVCVCV through onset addition, Welsh environment 129
Table 5.10 Word production attempts adapted to CVC and CVCVC through onset addition, English environment 131
Table 5.11 Word production attempts adapted to CVCV through onset addition, English environment 132
Table 5.12 Word production attempts adapted to the VCV template through onset omission, Welsh environment 133
Table 5.13 Word production attempts adapted to VCV through onset omission, English environment 134
Table 5.14 Number of attempts to produce various target types that matched the target in terms of coda production: Word-stage category comparison 135
Table 5.15 Adaptation to CV involving word-final coda omission, Welsh environment 138
Table 5.16 Adaptation to CV involving word-final coda omission, English environment 139
Table 5.17 Adaption to CVCV involving word-final coda omission, Welsh environment 140
Table 5.18 Adaptation to CVC involving word-final coda omission, English environment 141
Table 5.19 Adaptation to CVC involving word-final consonant addition, Welsh environment 142

Table 5.20 Adaptation to CVC involving word-final consonant addition, English environment *143*
Table 5.21 Comparison of target word syllable number data with Vihman (2000); Welsh and English environments *147*
Table 6.1 Mapping Ben's sessions according to word-stage category *155*
Table 6.2 Often occurring sounds grouped according to frequency; Ben, Welsh and English environments *162*
Table 6.3 Consonant inventories derived from words, Ben: Welsh and English environments *167*
Table 6.4 Proportion of all vocalisations identified as words with separate sessions depicted according to word-stage category, Welsh and English environments. *169*
Table 6.5 Ratio of target word tokens as compared to types, all participants: Welsh and English environments *170*
Table 6.6 Degree of match to target with regards to syllable number; Ben and TD group comparison: Welsh and English environments *172*
Table 6.7 Word production attempts adapted to CV through syllable omission, Ben: Welsh and English environments *174*
Table 6.8 Word production attempts adapted to CVCV through syllable addition and omission, Ben: Welsh and English environments *175*
Table 6.9 Multisyllabic adaptations through syllable addition, Ben: Welsh and English environments *177*
Table 6.10 Degree of match to target with regards to presence or absence of an onset; Ben and TD group comparison: Welsh and English environments *178*
Table 6.11 Word production attempts adapted to CV through addition of an onset; Ben: Welsh and English environments *179*
Table 6.12 Word production attempts adapted through onset omission; Ben: Welsh and English environments *180*
Table 6.13 Word production attempts featuring addition of an initial vowel; Ben: Welsh and English environments *181*
Table 6.14 Degree of match to target with regards to presence or absence of a coda; Ben and TD group comparison: Welsh and English environments *182*
Table 6.15 Word production attempts adapted to CV through omission of a coda, Ben: Welsh and English environments *184*
Table 6.16 Word production attempts adapted to CVCV through omission of a coda, Ben: Welsh and English environments *185*
Table 6.17 Word production attempts adapted to CVC through addition of a coda; Ben: Welsh and English environments *186*
Table 6.18 Comparison of overall variability ratios with separate sessions depicted according to word-stage category, Welsh and English environments *188*
Table 6.19 The rate of Ben's phonetic and lexical development across both languages *192*

List of figures

Figure 3.1 Typical layout of people and equipment during a recording session *65*
Figure 3.2 Summary of procedure for categorising vocalisations *69*
Figure 4.1 Percentage occurrence of consonants according to manner category; comparison of Welsh and English environments for all vocalisations and words only. *81*
Figure 4.2 Percentage frequency of occurrence of consonants categorised according to manner of articulation, Welsh environments. Occurrence within words depicted separately from all vocalisations. *82*
Figure 4.3 Percentage frequency of occurrence of consonants categorised according to manner of articulation – English environment. Occurrence within words depicted separately from all vocalisations. *83*
Figure 4.4 Overall percentage frequency of occurrence of consonants categorised according to manner of articulation – comparison of Beca's production across Welsh and English environments. *84*
Figure 4.5 Percentage frequency of occurrence of consonants categorised according to manner of articulation – Beca only. Occurrence within words depicted separately from all vocalisations. *85*
Figure 4.6 Percentage occurrence of consonants according to place category; comparison of Welsh and English environments for all vocalisations and words only. *86*
Figure 4.7 Percentage frequency of occurrence of consonants categorised according to place of articulation – Welsh environment. *87*

Figure 4.8 Percentage frequency of occurrence of consonants categorised according to place of articulation – English environment. 88
Figure 4.9 Overall percentage frequency of occurrence of consonants categorised according to place of articulation – comparison of Beca's production across Welsh and English environments. 90
Figure 4.10 Percentage frequency of occurrence of consonants categorised according to place of articulation – Beca only 92
Figure 4.11 Changes in inventory size over time in relation to number of vocalisations produced 99
Figure 4.12 Number of consonant types as compared to the number of vocalisations produced 99
Figure 4.13 Number of consonant types produced in words over time. Welsh and English environments 101
Figure 5.1 Word shape inventory, target word types: Welsh and English environments 112
Figure 5.2 Most frequently occurring shapes for word production attempts according to target word syllable number and the language of the environment 113
Figure 5.3 Word production attempts of differing lengths according to the number of syllables within the target word: Between-child cross-linguistic comparison 117
Figure 5.4 - Word production attempts of differing lengths according to the number of syllables within the target word: Within-child cross-linguistic comparison 118
Figure 5.5 Word production attempts with and without onsets according to structure of target word: Between-child cross-linguistic comparison 126
Figure 5.6 Word production attempts with and without onsets according to structure of target words. Within-child cross-linguistic comparison. 127
Figure 5.7 Word production attempts with and without codas according to structure of target word: Between-child cross-linguistic comparison 136
Figure 5.8 Word production attempts with and without codas according to structure of target word: Within-child cross-linguistic comparison 137
Figure 5.9 Overall variability ratios for each session; Welsh and English environments 144
Figure 6.1 Number of word types produced in each 30-minute session. 154
Figure 6.2 Frequency of occurrence of manner categories across all vocalisations and all session; Ben and TD group comparison, Welsh and English environments. 157
Figure 6.3 Changes in the proportion of consonants produced belonging to each manner category across all vocalisations, Welsh and English environments. 158
Figure 6.4 Frequency of occurrence of place categories across all sessions, Welsh and English environments. Depicted separately for all vocalisations and words; Ben and TD group comparison. 159
Figure 6.5 Changes in the proportion of consonants produced belonging to each place category across all vocalisations, Welsh and English environments. 161
Figure 6.6 Consonant with >20% occurrence across all vocalisations, Welsh and English environments 163
Figure 6.7 Size of consonant inventory at each data point, analysis of all vocalisations produced, Welsh and English environments 164
Figure 6.8 Number of vocalisations produced alongside number of consonants present in inventory for each session, Ben, Welsh and English environments 165
Figure 6.9 Size of consonant inventory at each data point, analysis of words only: Welsh and English environments 166
Figure 6.10 Proportion of vocalisations identified as words across all sessions. 169
Figure 6.11 Word shape inventory, target word types; Ben, Welsh and English environments 171
Figure 6.12 Word production attempts of differing lengths according to the number of syllables within the target word: Within-child cross-linguistic comparison 173
Figure 6.13 Word production attempts with and without onsets according to structure of target words: Within-child cross-linguistic comparison 178
Figure 6.14 Word production attempts with and without codas according to structure of target words: Within-child cross-linguistic comparison 183
Figure 6.15 Overall variability ratios for each session; Ben: Welsh and English environments 187

1 Introduction

Within the study of linguistics, there seems to be discord between that which is abstract, formal and therefore predictable, and that which is concrete, highly variable and difficult to formalise (Pinker, 2013). Linguistic knowledge is complex and multi-dimensional. It is seen by some as intangible and therefore impossible to learn; governed by rules and formulae therefore unlikely to be borne out of the apparent chaos that is spoken words and sentences (Tomasello, 2003). Whilst it is agreed that we are not consciously aware of it, there is disagreement regarding the exact nature of this knowledge and how we come to be in possession of it. On one side of the argument are those who believe that linguistic knowledge is innate and therefore universal (e.g. Chomsky, 1987; Pinker, 2007) whilst on the other side, there are those who believe that linguistic knowledge is individual and learnt through experience (e.g. Evers-Vermeul and Tribushinina, 2017). Within this thesis, the study of language and its acquisition is approached from a usage-based and cognitive linguistic perspective (Tomasello, 2003).

Phonology can be conceptualised in terms of the universal aspects of sound patterns as well as a language-specific map that governs the structure and content of utterances (Davenport and Hannahs, 2010). Subtle adjustments in the placement and movement of articulators result in the production of sounds that are phonetically distinct. The study of phonology is concerned with the relationship between these changes and the possible change in meaning that ensues. However, phonological knowledge is typically seen as abstract and is therefore somewhat removed from the reality of sound production in most theoretical approaches – a motor and sensory act (Burton-Roberts, Carr and Docherty, 2000). In contrast, in the usage-based approach adopted here, phonology is procedural involving the construction of a system whilst in use, built according to words and patterns frequently heard and spoken (Bybee, 2001; Pierrehumbert, 2003).

The study of child phonology is concerned with investigating the emergence and construction of this system in the context of development. Development is a journey that can be conceptualised in stages, akin to walking up steps. Through increased experience and

interaction with the world, each stage builds upon the previous one. For a hearing child, the world around them is characterised by sound and the child becomes adept at focussing their attention on the verbal language(s) they hear (Vihman, 2014). With each passing month, the sum total of words and sentences experienced increases as the child is immersed in the language(s) spoken by his or her caregiver(s). Governing the structure and content of the language is its phonological system, construction and mastery of which is the ultimate goal for the child in terms of speech learning. The child must learn to parse, decode and therefore perceive the sounds they encounter via the speech stream (Werker and Tees, 1984). Speech perception is a complex neurological process involving input and storage of information. The precise nature of this input influences the form and content of the storage structures (Bybee, 2001).

Alongside the development of speech perception mechanisms, the child begins to vocalise as the air leaves their lungs. Sound production moves from automatic, or reflexive, to purposeful. Interaction with caregivers begins through vocal play and facial expression and develops into the production of recognisable words, at around 12 months, marking the beginning of language use (Vihman and McCune, 1994). Early words are likely to be context-specific as the child attempts to imitate what they hear, within the parameters of their current articulatory abilities (Vihman, 2017). Early word production patterns can be attributed to the language-specific structure and content of the vocalisations encountered along with language-general commonalities resulting from anatomical and physiological limitations. These limitations are common to all infants and have been posited as the reason behind similarities within the first words seen across a variety of language environments (Boysson-Bardies and Vihman, 1991). Developed through babble during the preceding months, specific sequences of motor movements, or *motoric frames*, are deployed in word production attempts (Davis and MacNeilage, 1995). The contents of the child's vocalisations, both in terms of segments and syllables, are also influenced by the language(s) encountered within their environment at this time.

The single-word period is denoted as the period where vocal production is characterised by the production of single words. It extends from the appearance of first words, through lexicon expansion, and ends when the child begins to produce two-word utterances. This typically takes place around the end of their second year (Capirci *et al.*, 1996). During this period, implicit and explicit learning mechanisms developed through experience lead to

identification of the regularities found within the utterances they hear (Velleman and Vihman, 2002). This, in turn, leads to the construction of the necessary phonological system(s) required to underpin ongoing language learning and use (Vihman and Croft, 2007). A move towards word combination by the end of the second year is seen as an important indicator of success within speech and language acquisition (Wren *et al.*, 2016).

This process is subject to a large amount of individual variation, with children responding to the challenge of speech development in different ways. There are overall trends in terms of earlier and later appearing sounds but the exact sequence of emergence cannot be predicted (Morgan and Wren, 2018). Recording of children's early vocalisations has shown that the profile of sounds produced by a child as they begin to experiment with sound production is far more varied than that which they deploy when making their early attempts to produce words. Sounds that occur frequently within their pre-linguistic vocalisations tend to be prevalent in their early words (Keren-Portnoy, Majorano and Vihman, 2009; Majorano and D'Odorico, 2011).

The process of speech development is subject to a set of expectations borne out of the study of various cohorts of children and the analysis of their word production abilities in relation to their age (Dodd *et al.*, 2003). These expectations have clinical implications and for children who do not seem to be following the expected trajectory, it is vital that we have the necessary tools to characterise their difficulties and effect positive change (Dodd, 2013).

There is an inextricable link between the nature of the linguistic input and the speech production behaviours observed. Consequently, speech development is different when it occurs in the presence of two languages, as opposed to one. The production of meaningful utterances in two languages relies on the construction of two phonological systems. Rather than existing in isolation, these systems relate to one another and this interaction leads to a different developmental profile, as compared to children learning a single language (Keffala *et al.*, 2020). As discussed above, the structure and content of the language input received provides the basis for construction of the phonological system. The study of bilingual phonological acquisition allows for investigation of the relationship between input and speech sound production. By examining speech production behaviours in different language environments, the degree of influence imposed by the ambient language can be established.

In addition to this, the convergence and divergence of patterns across the two language systems can be studied allowing for the exploration of theoretical implications.
For bilingual children learning two languages that are independent from each other in terms of historic and current use, these cross-linguistic influences will be as a result of synchronic transfer within the individual. However, in contexts were two languages are in contact, and this contact is historic, there are additional sources of influence that need to be considered (Morris, 2021). This is the case within Wales.

Welsh-English bilinguals reside mainly in Wales, although there are small numbers of them residing in other countries throughout the world. Welsh is a Brythonic Celtic language that has been spoken continuously in Wales throughout recorded history. Speaker numbers have fluctuated over time with English being adopted throughout Wales due to colonialisation (Coupland and Thomas, 1990). This led to a population that included individuals with various linguistic experiences, including monolingual English speakers residing in Wales as well as Welsh-English bilinguals with varying degrees of exposure to both languages.

By now, Welsh and English are official languages in Wales with the latest Annual Population Survey reporting speaker numbers at 884,300, amounting to 29.2% of the population, aged 3 and over (Welsh Government, 2021). However, speaker numbers fluctuate across different parts of Wales and the variation in the proportion of speakers across districts, and indeed individual communities, means that levels of exposure experienced by children living in Wales can vary greatly. Welsh is present within all schools, either as the language of instruction or taught as a second language. Primary schools in Gwynedd, an area where 76% of people speak Welsh (Welsh Government, 2021), are exclusively Welsh-medium thus providing education for those exposed to Welsh from birth and immersion education for children from English-speaking homes (Hickey, Lewis and Baker, 2014). For the majority of people within these communities, Welsh is an integral part of their everyday lives and is the predominant language of local government procedures and civil processes.

For children not yet attending formal education, their main source of language input will be within the home. Once they begin attending a Welsh-medium primary school, they will likely become bilingual within their primary years. The nature of the language exposure will be unique to each individual and the speech production behaviours needed will develop in accordance with the input (Vihman and de Boysson-Bardies, 1994). A single-language home

will result in the initial acquisition of skills relating to one language, either Welsh or English, with the introduction of a second language, either in school (in the case of Welsh) or through interaction with the wider society and the media (in the case of English), resulting in sequential bilingualism. A dual-language home environment will result in simultaneous bilingual development with the acquisition of skills relating to both languages occurring in parallel, albeit uneven due to differing amounts of language exposure relating to different situations, people or activities (De Houwer, 2009).

However, despite home environments being limited to one language, children residing in Gwynedd are living within a bilingual community. Locally-raised parents are themselves likely to be bilingual and whilst their child-directed talk may by limited to one of their languages, both will be utilised for interactions within their social and work contexts. In the case of parents who are monolingual, children will experience dual-language contexts and encounter others using two languages. Differentiation between the two languages, from a very young age, will therefore be necessary in terms of directing their attention to the one language whilst disregarding the other (Grech and Dodd, 2008).

The study reported in this thesis aimed to explore ambient language influence on speech patterns within the single-word stage, a critical period of development. In the context of societal bilingualism and an area of Wales where the majority of residents speak Welsh, the study of the speech production behaviours of children at this stage allowed for conclusions to be drawn regarding development of segments in pre-speech and early words as well as structural patterns seen in the production of syllables and words. There are few studies to provide a systematic, longitudinal account of this stage of development in bilingual children. The specific language pairs involved have a bearing on the nature of ambient language and cross-linguistic influence. This study is the first account of this kind to focus on development of both consonants and words in children who are residing in a Welsh-English community and are currently bilingual or going to be bilingual in the future.

To this end, the extent to which the speech production patterns observed were influenced by the phonetic, phonological and phonotactic characteristics of Welsh and English were investigated. Questions surrounding the intertwining of linguistic and biological factors were addressed through detailed analysis of early vocalisations produced by children residing in

both single- and dual-language homes. In Gwynedd, North Wales, where the study is set, Welsh is the majority language so children who reside there are likely to encounter both languages within their everyday environments with the amount of input they receive in Welsh and English being dependent on the language(s) being used within the home. Undertaking this study in a community where linguistic diversity is commonplace allowed for exploration of both individual and societal bilingualism, as well as investigation of how these factors intersect.

From the findings of this study, conclusions were drawn regarding the rate and nature of speech development in Welsh-English bilingual children, thus adding to the few existing studies on the topic. Although the initial aim of this study was to capture variations within typical development and participants were recruited in line with this aim, the speech development of one of the participants was atypical. This gave rise to a unique opportunity to study the vocal behaviour of a bilingual child before it became apparent that his development was not following the expected developmental trajectory. The study of children residing within a bilingual community allowed for the examination of the effect of language contact on patterns within early development. Typical and atypical speech production patterns were depicted which could support the development of assessment and intervention tools aimed at meeting the specific needs of children residing in Wales.

This thesis will begin by reviewing the relevant literature on speech development with a particular focus on the single-word period due to its relevance for the investigation of the emergence of a phonological system. Discussion of the literature in Chapter two will focus on phonetic and phonological acquisition in monolinguals and bilinguals, as well as atypical speech development. Chapter three will then report on the methods used within the study, providing details on the participants involved and procedures used for data collection and analysis. Three results chapters will follow, the first of which will report on consonant development across the period examined, with a focus on cross-linguistic differences within and between subjects. Chapter five will move away from segmental development and take a whole-word approach. This chapter will contain data regarding word and syllable shapes produced across Welsh and English.

The data from the child deemed to be displaying atypical development will be discussed separately within chapter six where both segmental and whole-word patterns will be

investigated. Chapter seven will be a general discussion of the themes that have emerged through collection and analysis of these data. Here the aim of the study and the research questions posed will be revisited in the context of the data presented, providing insights into the nature of the developmental trajectory, the role of the ambient language and early atypical patterns in the context of bilingual development.

2 Speech development in children

2.1 Introduction

Accurate speech production is essential for conveying meaning through talk. When engaged in verbal conversation, we use our articulators to shape the air as it leaves our lungs in such a way that recognisable words are produced (Vorperian *et al.*, 2005). The majority of adults execute these movements seemingly effortlessly, unaware of the narrow tolerances that necessitate precise articulator positioning and timing. Imprecision leads to perceptible differences in the sounds produced and changes in meaning leading to possible breakdowns in communication. For many of us, this is a rare occurrence; one that is shrugged off as a 'slip of the tongue', corrected as soon as we perceive it due to our self-monitoring abilities. When a child is born, they do not possess any of these skills, yet somehow by the time they have their first birthday, many have begun to produce words that are recognised by their caregivers (Lust, 2006). Thus, they have begun to influence their world through talking. By the time they have their second birthday, they may well be producing short phrases and using them to fulfil a variety of functions such as commenting, requesting and questioning (Capirci *et al.*, 1996). But how do children learn to produce speech sounds within words in order to convey meaning? What mechanisms are employed within the process that allow a child to go from reflexive crying, that has the purpose of drawing attention to their immediate needs, to participating in a multi-turn conversation to negotiate which bedtime story they would like and who they would like to read it to them?

At this early stage of linguistic development, when first words are emerging, the construction of a phonological system is just beginning (Vihman and Velleman, 2000; Vihman, 2017). Being able to produce intelligible speech is an important feature of child development. This is a gradual process, with non-adult like speech patterns being developmentally typical in young children (Dodd *et al.*, 2003). As a child grows older, however, speech errors can signal a difference between them and their peers. This can lead to social isolation, ridicule and a failure to meet the necessary educational milestones (Anthony *et al.*, 2011; McCormack *et al.*, 2010; McLeod, Daniel and Barr, 2013). For children who experience difficulties learning how to produce age-appropriate speech, assessment and management of their needs is required, often relying on the identification of the possible underlying reasons for those difficulties (Dodd, 2013).

This chapter will first provide an overview of early speech development in monolingual and bilingual children before going on to explore what happens when this process does not follow the expected trajectory. In accordance with the theoretical stance being taken within this thesis, the discussion will align with a usage-based approach (Bybee, 2001; Pierrehumbert, 2003). As the phenomenon of speech development is explored from this perspective, the child is portrayed as an active participant within the developmental journey, utilising their various experiences in the context of their ongoing neuroplasticity. A review of current perspectives in relation to these topic areas will provide a basis for the study that is introduced at the end of this chapter and reported on in the remainder of the thesis.

2.2 Developing phonological knowledge through experience

Children must draw on phonological knowledge in order to produce intelligible speech. The process by which they come to be in possession of this knowledge is known as *phonological acquisition* or *phonological development*. These terms are often used interchangeably, as they both refer to the period before speech production is adult-like. But if they are viewed to have a more specific focus, it can be seen that they relate to divergent theoretical underpinnings. If the child is said to *acquire* this knowledge, they are couched in a passive role. This seems to be in accordance with formalist approaches where knowledge of the structure of language is said to be innate and the child acquires further language-specific knowledge through exposure to linguistic stimuli (Chomsky and Halle, 1968; Kager, Pater and Zonneveld, 2004). This view is supported by discussion of the challenges facing the child when mastering the highly complex act of conveying meaning through talk in such a small timeframe. The highly variable nature of the input and seemingly random manner in which it is deployed by their caregivers is also emphasised (Chomsky, 1987; Pinker, 2013).

The task does seem impossible when we liken the process to building a pyramid from individual blocks. The builder would need to know the size and shape of each block, have knowledge (or at least a hypothesis) of how the blocks would fit together and a blueprint (a mental one at least) of the end product. If we apply this to a child constructing their phonological system, they would need to be aware of the individual segments that make up the system (which is pretty impossible given that these segments do not appear in isolation within conversational speech), they would need to know all of the ways segments pattern

together to form words as well as which combinations are not allowed and they would need knowledge of the structure for which they are aiming.

However, in nature there are multiple examples where individual components interact without a predetermined plan nor external influence, and order emerges from apparent chaos. This type of system is described as a *complex* or *dynamic* system as it is characterised by a high degree of behavioural variability and therefore subject to flux (De Bot, Lowie and Verspoor, 2007; Cameron and Larsen-Freeman, 2007; Thelen and Smith, 1996). These systems, termed self-organising due to the non-linear interaction of components, have remarkable abilities when it comes to change and development. Through consistent cooperation in a variety of modes the components of these systems initiate the appearance of new, ordered structures which are far removed from the properties of the individual elements. These new forms emerge at points when there is a decrease in the system's equilibrium. Complex systems are subject to inherent and unavoidable fluctuations and at critical points these fluctuations begin to dominate, manifesting in variable, transient behaviour. This instability initiates the search for new patterns or strategies and the system evolves into a new stable state bringing with it a decrease in variability.

This is how phonological *development* (a far more useful term than acquisition for the purposes of this thesis) is described within functionalist theories. Here the emphasis is on learning through experience, with phonological knowledge being constructed through language use (Pierrehumbert, 2003). Functionalist theories address how a child gains linguistic knowledge in the absence of an innate structure (or mental blueprint) on which to draw. Central to this type of approach is the notion that alongside speech perception and production, phonological development is a result of general cognitive processes such as shared attention, working memory and pattern recognition (Beckner *et al.*, 2009; Bybee, 2001). The child is an active learner extracting information from the stimulus material and building the required knowledge as they go along.

Phonology is described by Bybee (2001) as a complex system with emergent properties in that structure is derived from the repeated application of simple constructs. Therefore, the existence of structure does not depend on the initial existence of a predetermined plan. Instead, the child utilises developing perceptual and motor abilities through deployment of *statistical* and *declarative* learning mechanisms. Very young infants have a predisposition to

attend to the salient characteristics of human speech and they become more attuned to the language within their environment as they progress through their first year (Bosch and Sebastián-Gallés, 1997). Thus the ambient language has a significant effect on both speech perception and vocal production (Vihman, 2009). As a child gathers linguistic experience, they begin to accumulate *statistical* knowledge of the distributional regularities (Saffran, Aslin and Newport, 1996). Through this powerful learning mechanism, a child knows which combinations of sounds are more likely to occur, and through this they are able to recognise word boundaries and begin to extract salient portions of the speech stream to inform their speech and language development (Saffran, Aslin and Newport, 1996).

As the child participates in vocal behaviour, repetitive movements of the articulators create routines, or schemas, which become motorically accessible (Bybee, 2001). These movements are governed by a combination of anatomical factors and individual preferences. Described as a *declarative* or *experiential* learning system that is typically put into practice at around 12-18 months, the development of attentional control coincides with the acquisition of these abilities which leads to the creation of associations between certain sound patterns and occurrences within the environment (Vihman, 2009). This ability to retain both semantic and phonetic representations leads to the formation of a lexical knowledge base, or lexicon.

Once the child has access to an incipient lexicon, distributional learning is employed once again. This time, the regularities are not drawn from sensory information; they are drawn from within the child's own lexical knowledge base (Vihman, 2009). General assumptions are made based on existing representations leading to the gradual creation of an abstract system. This system is an example of the type of complex self-organising system whereby the components are subject to continual changes in structure and organisation (Larsen-Freeman, Schmid and Lowie, 2011; Thelen and Smith, 1996; Beckner *et al.*, 2009). The template-based approach to segmental phonological representation put forward by Vihman and Croft (2007) is based on these premises.

The concept of whole-word phonology has been described as taking "an emergentist and usage-based stance before its time" (Vihman and Keren-Portnoy, 2013 p.1). It was first put forward in the 1970s by Waterson (1971), Ferguson and Farwell (1975) and Macken (1979), their papers centring around the child constructing their own production patterns based on whole-word shapes. It is thought that children employ a lexically-based method of

organisation during the initial stages of word production (Vihman and Croft, 2007). This notion was expanded by Pierrehumbert (2003) who described word learning as item-based in her exemplar theoretic approach. This means that each time a word is encountered, a memory trace is created, with the trace containing detailed information about the form of the stored word.

From these initial accounts of phonological development came a series of studies carried out by Vihman and colleagues where children's vocal behaviour at the beginning of their second year was recorded and carefully analysed with the aim of identifying templates (Vihman and Croft, 2007; Keren-Portnoy, Majorano and Vihman, 2009; Velleman and Vihman, 2002; Vihman, 2016; Vihman, 2009; Vihman, 2010; Vihman and Kunnari, 2006). Vihman and Croft (2007) bring together the findings of previous studies in order to put forward the templatic approach to segmental phonological representation with discussion of how this could be applied to both child and adult forms. Within the template-based approach, it is argued that statistical and declarative learning combine to utilise the linguistic resources available within the speech a child hears all around them and the motor abilities amassed by vocal practice to produce early words (Vihman and Croft, 2007). These mechanisms give rise to certain word and syllable shapes within their productions. These patterns, or templates, are idiosyncratic but they do share the commonalities seen to characterise children's early word productions. Velleman and Vihman (2002) posit that children are able to perceive, store and recreate whole words through utilisation of implicit and explicit knowledge. Implicit knowledge is amassed through distributional learning; it is acquired from the child's linguistic experience allowing them to specifically attune to those words within the input that resemble their commonly produced articulatory patterns. Explicit knowledge, on the other hand, is gained through experiential learning. The act of vocal practice leads to some articulatory routines becoming more motorically accessible and therefore occurring within a child's first words. The implicit knowledge possessed by the child contains information regarding the segmental and supra-segmental characteristics of the language they are being exposed to within their environment, while their explicit knowledge contains information on how to recreate these sounds and sound sequences. The earliest words to emerge, known as *selected forms*, are created through the integration of implicit and explicit knowledge. They are often a relatively close match to the adult target. As the lexicon expands, a word-based method of representation and storage becomes impractical which leads to the emergence of a phonological system. This learning mechanism provides the

basis for our understanding of speech development, but further detail on the various stages within the process is needed in order to fully appreciate its contribution and relevance. To this end, the early stages of speech development in children will now be discussed.

2.3 Early speech development

In order to understand the nature of speech development, it is important to begin our exploration before the child has produced a single word. At the beginning of life, children cannot convey specific messages to those around them as they are unable to produce words and sentences (Lust, 2006). Becoming part of the surrounding linguistic world requires them to accumulate a specific set of skills (Bybee, 2001). Birth marks the beginning of a journey where the information received and stored is shaped by the way a child interacts with the environment, leading to the development of abilities unique to humans (Jusczyk, 1997). With the aim of providing details of the journey a hearing child takes as he or she receives and produces sounds that will later become part of their 'language', this section will look closely at the journey from birth to the production of words and the development of a phonological system. Each stage is vital to the overall speech development process and consideration will be given to both biological and linguistic factors as a spotlight is placed on this complex dynamic process.

2.3.1 Speech perception

The first part of the speech development process to explore is speech perception. It logically comes at the start of the process as it is seen as a precursor to phonological development and it can be observed as soon as the child is born (Werker and Pegg, 1992; Werker and Yeung, 2005). The hearing child begins to hear sound whilst in the womb and their experience of sound continues throughout their life (Karmiloff and Karmiloff-Smith, 2009). Despite the commonality of the experience of hearing the speech of those around them, each child encounters an auditory experience that is unique to them. These individual experiences, in turn, lead to the demonstration of some behaviours that are seen to be shared across different children and various language environments (Vihman, 2014). Careful investigation of these behaviours in the presence of different auditory stimuli provides insights into this complex process whereby the child makes sense of the plethora of inputs they are hearing.

Investigations documenting that new born babies can show preference for their native language just after birth suggest that children begin to attune to speech produced around them whilst still in the womb (Kuhl, 2004). Through demonstrating preference for familiar sounds and sensitivity to those that are novel, insights are gained into the process that underpins speech perception, and adjustments made to the nature of the stimuli allows for conclusions to be drawn regarding the specificity of these abilities at different points (e.g. Moon, Cooper and Fifer, 1993; Best and McRoberts, 2003; Escudero and Kalashnikova, 2020). For example, Moon, Cooper and Fifer (1993) found that two-day-old babies demonstrate native language preference.

Languages differ at the prosodic level with rhythm, stress and intonation manifesting in various ways. There are also segmental and subsegmental differences seen when languages are compared (Maddieson and Disner, 1984). Other differences relate to ways in which these segments pattern together within a given language. As previously discussed when describing the learning mechanism that underpins speech development (section 2.2), paying repeated attention to events in the speech input heard by the child leads to the identification of patterns. Paying attention to various language-specific elements allows the child to pick out salient aspects, and separate words and syllables within the continuous speech stream (Christophe *et al.*, 2003).

It was originally thought that the ability to discriminate from such an early age was dependant on distinctions associated with broad rhythmic qualities (Mehler *et al.*, 1988) but it was then revealed that babies could in fact discriminate between two languages that belonged to the same rhythmic class (Bosch and Sebastián-Gallés, 1997, 2001, 2003; Sebastián-Gallés and Bosch, 2009). Being able to discriminate between two such languages as Spanish and Catalan indicated that there was a sensitivity to differences finer than broad rhythmic class. This prompted the question of whether infants could identify differences related to segments.

There is consensus in the literature that infants' early perception and discrimination abilities are not dependent on their linguistic experience. This means that they are able to discriminate contrasts that do not signal meaning in their native language or languages (Jusczyk, 1997; Vihman, 2014 provides a review). But through a process known as *perceptual narrowing*, this ability decreases as they progress through their first year due to increased exposure to the language of the environment and thus the native contrasts (Werker

and Tees, 1984; Kuhl *et al.*, 2005; Curtin, Byers-Heinlein and Werker, 2011). However, the reduction in ability to discriminate non-native contrasts should not be seen as the total loss of a skill once possessed. Instead, it should be seen as a reorganisation of perceptual abilities (Anderson, Morgan and White, 2003; Werker, 1994).

2.3.2 Early vocalisations

As a child interacts with their environment, they begin to produce sound. The child has access to internal and external resources as they attempt to acquire the skills needed to execute these new behaviours, which are governed by biological and linguistic factors. The earliest sounds are formed by the passage of air firstly through the larynx where vibration occurs and then through a relatively unobstructed oral cavity. These sounds are often described as 'coos' and have a vowel-like quality (Johnson and Reimers, 2010). As the child grows, they are able to exert an increasing amount of control over their articulators and because of this, vocalisations become more varied. This varied movement begins to produce rhythmic alternation between periods of free-flowing air and periods of constricted air and the first syllables are produced. Increasingly complex vocalisations are produced as the child becomes more proficient at placing and moving their articulators, thus able to produce sounds in sequence.

Development of communicative competence begins at the pre-linguistic stage. Alongside learning about their place in the world and how to interact with others, the child must develop the ability to purposely vocalise and those vocalisations need to be recognisable to their interlocutor in order for communication to be successful (Vihman, 2014). Vocal development within the pre-linguistic stage can be conceptualised as a series of stages. Each stage is said to feature a preponderance of a certain vocalisation type, but this does not mean that other vocalisation types cease to be present. In fact, there seems to be agreement in the literature that there is a degree of overlap between the stages and an increase in the frequency and variety of speech-like vocalisations as the child progresses through their first year of life (Smith, Brown-Sweeney and Stoel-Gammon, 1989; Fagan, 2009; Morgan and Wren, 2018).

There is limited consensus regarding the precise developmental progression through the pre-linguistic phase and the nature of these vocalisations can be linked to a number of factors.

Firstly, vocal production is dependent on the stage of vocal tract maturation and level of ability in terms of motor control (Vorperian *et al.*, 2005). Secondly, the language-specific characteristics of the language(s) of the environment influence the structure and content of the vocalisations produced (Vihman and de Boysson-Bardies, 1994). Thirdly, there is a great deal of individual variation seen at this stage of development, thus limiting the assertions that can be made regarding the expected developmental trajectory (Morgan and Wren, 2018; Vihman, Ferguson and Elbert, 1986).

Many studies have shown that from the onset of babbling, at around 7 months, the child produces a growing number of vocalisations demonstrating increasing complexity up until their first birthday and beyond (Morgan and Wren, 2018; Mitchell and Kent, 1990; MacNeilage, Davis and Matyear, 1997; Rome-Flanders and Cronk, 1995; Nathani, Ertmer and Stark, 2006). The definition of complexity, however, differs between studies. For example Davis and MacNeilage (1995) make the distinction between reduplicated babble, which contains repetitions of identical or very similar syllables across the babbling string, and variegated babble which is characterised by a variety of consonant and vowel segments being produced across the syllables. Nathani, Ertmer and Stark (2006), on the other hand, associate complexity with the presence of consonant clusters or syllables with vowel onsets. Fagan (2009) conducted a longitudinal investigation of the characteristics of vocalisations produced by 18 infants starting at 3 months and continuing until the onset of word production. The study involved recording both naturalistic and semi-structured play with a parent, and analysis of the vocalisations produced in terms of vocalisation type, length of utterance and the collection of longitudinal data allowed for mapping of changes over time. The findings revealed that many of the infant vocalisations were short and structurally simple up until 12 months. There was a spike in the frequency of reduplicated strings at around 9 months of age, which seemed to coincide with an increase in rhythmic motor movements of the arms and legs.

Pre-speech vocalisations are influenced by the particular anatomy and physiology of the vocal tract and associated muscles. The range of movements available to these structures are limited at this age with an increase in the range and control of movements expected as the child develops (Vorperian *et al.*, 2005). The consistency in the structure and content of these vocalisations is thought to be a result of these limitations (Davis and MacNeilage, 1995; Lee, Davis and MacNeilage, 2010). The *Frame-Content Model* asserts that mandibular oscillation

provides the foundation (or 'frame') for the vocalisation, and more detail (or 'content') is then added in the form of segments, as the child exhibits greater control over their lips and tongue (Davis and MacNeilage, 1995; Serkhane *et al.*, 2007). Close inspection of the repetitive consonant-vowel (CV) strings produced at this stage, known as *canonical babble*, reveals a relatively small range of sounds being produced with a preponderance of labial consonants interspersed by central vowels (Lee, Davis and MacNeilage, 2010). Reference has been made to the shape and content of these vocalisations in relation to the Frame-Content model which appears to be the theory most widely referred to within discussions of the influence of biological factors. Further support for the influence of the anatomy and physiology of the speech production apparatus on the shape and content of the vocalisations produced can be gained from studies that have found broad similarities in the vocalisations of children experiencing different ambient language environments. For example, Lee, Davis and MacNeilage (2010) collected data from six children between the ages of approximately 0;7 and 1;0 who were being exposed to Korean and compared them to data collected from children exposed to English. The findings of this study demonstrated many similarities in the consonants and vowels produced by children aged 0;7 to 1;0 learning English or Korean that cannot be explained by overlapping features of the two languages.

However, there exists a sizeable body of research that argues for the presence of ambient language effects, making connections between the structure and content of vocalisations produced and the segmental and supra-segmental characteristics of the language or languages that are present. De Boysson-Bardies and Vihman (1991) demonstrated that the vocalisations of twenty children from four different language environments differed significantly in the frequency of distributions of consonant manner and place, differences that were mirrored within the frequency distributions seen in adult target words. More recently, in a study on the vocalisations of forty-three children between the ages of 0;10 and 1;6, Rvachew, Mattock and Polka (2006) showed that children exposed to English had different developmental patterns from those exposed to French. Rvachew *et al.* (2008) supported these findings through demonstration of cross-linguistic differences in the distributional frequency of corner vowels within the same children's productions. In like manner, Lee *et al.*'s (2010) study revealed that children exposed to Korean produced more nasals and fewer glides and fricatives than children exposed to English. This difference was reflected in the frequency distribution of these consonants within the infant-directed speech samples for Korean and English.

There seems to be a lack of clarity in the literature regarding the description of different types of pre-linguistic vocalisation. In particular, decisions surrounding inclusion or subsequent categorisation of utterances that do not contain well-formed supra-glottal consonants are complex. With the aim of measuring variables, such as changes in utterance duration over time, Ramsdell-Hudock, Stuart and Parham (2018) coded the vocalisations of 15 children at 2-month intervals between 8 and 16 months. Vocal type was defined in terms of modal pitch range and a code of growl, vowel or squeal was assigned for pitch that was perceived to be lower than, within and higher than the typical modal range for that child, respectively. Interestingly, the authors note that all utterance types contained both vowel-like and consonant-like segments that were well-formed to varying degrees. In contrast, in an investigation of the vocalisations of 9-month-old babies Chapman *et al.* (2001) coded and categorised canonical utterances based on number of syllables. In investigating the frequency of different consonant types, they found the production of glottal consonants to be common in cleft and non-cleft children with 80% of the non-cleft group producing glottal stops within their vocalisations. Lee *et al.* (2018) evaluated all-day vocalisations of 14 children and judged each vocalisation to be either an example of canonical babbling or to be without canonical syllables. In contrast to the other studies discussed here, syllables with vowel-like nuclei but no supraglottal articulation i.e. those featuring glottal stops were included in the latter category and were therefore not deemed to be canonical syllables.

Fagan (2009) did not differentiate between marginal and canonical syllables as they identified and coded the vocalisations of the infants in their study. They did, however, code vocalisations that contained a supra-glottal consonant separately giving rise to frequency data of these types of vocalisations at each age point. The results of the study showed that 49% of all utterances analysed did not contain a supra-glottal consonant and of the remainder, 32% contained only one. This result demonstrates the prevalence of glottal consonants within early vocalisations and the importance of not excluding them from these types of investigations.

In McCune *et al.* (1996), there is an additional vocalisation type identified which they term *grunts*. Grunts are defined as abrupt sounds produced when there is glottal closure followed by quick release either through the mouth or nose if the lips are closed. McCune *et al.* (1996) investigated the grunt productions of five children between the ages of 8 and 24 months. The study found that grunts are first produced automatically in response to effort or attention, but

their communicative use increases as children grow. The authors propose that the occurrence of this, at first involuntary, vocal behaviour at specific times leads to its reproduction by the child of its own accord in the absence of a physiological need. This could be seen as the earliest voluntary use of vocal behaviour in that it leads to the production of early words once the child is able to make the necessary sound-meaning correspondences. Grunt production is said to predict the onset of referential language where sufficiently developed social and cognitive abilities are present and phonological development is otherwise appropriate (McCune, 1992). The term is also used within other studies without the emphasis on communicative intent, listed under the 'primitive vocalisation' category alongside laughter and exclamations by Rome-Flanders and Cronk (1995) and given as an example of a 'vegetative noise' by Fagan (2009).

Despite the apparent heterogeneity of vocal behaviour during this period, a move from the more motoric acts of vocal play seen within the babbling phases towards vocalisations that can be described as speech-like has been shown in various ways. This progression has been illustrated by an increase in segmental and structural complexity as the child gets older (e.g. Vihman, Ferguson and Elbert, 1986). It also seems to be marked by a gradual alignment with the phonetic, phonological and prosodic aspects of the language(s) to which they are being exposed as the children increase in age (e.g. Majorano and D'Odorico, 2011). This will be discussed further in the following section where the focus moves to early linguistic abilities.

2.3.3 Speech production in the single-word period

As the child begins to display the necessary motoric control to produce vocalisations with the complexity needed for the production of recognisable words, they also demonstrate that they are becoming aware of sound-meaning links, as demonstrated by the use of gesture and eye-contact. The child is able to attend to adult word production and make associations in terms of form and use, allowing them to match the adult target and extend its use to new, relevant situations (Vihman and McCune, 1994). At this point, the symbolic use of words has begun.

Jakobson (1968) proposed that there was no relationship between this stage and the pre-speech phase (outlined in 2.3.2) and that the two developmental stages should be regarded as entirely separate. His *discontinuity hypothesis* described babbling as purely motor practice

not linked in any way to the production of words, which he saw as marking the beginning of linguistic development. There are by now various studies that feature detailed analyses of vocal production of children during this period (e.g. Elbers, 1982) which provide clear evidence that babbling continues alongside the emergence of recognisable words, thus strongly contradicting Jakobson's discontinuity hypothesis. Further support has been given to the notion of continuity between the stages by studies evidencing the commonalities seen within the segmental and supra-segmental characteristics of vocalisations produced (Kern, Davies and Zink, 2009; Majorano and D'Odorico, 2011; McCune and Vihman, 2001; Oller and Eilers, 1982; Vihman, 2010; Vihman *et al.*, 1985). Such studies go so far as to assert that there is a restricted set of sounds and syllable structures that characterise early word productions, and that this remains true across a range of different language environments (Vihman, 2010). First words tend to be monosyllabic or disyllabic, and they tend to contain plosives or nasals produced at the front of the mouth (Stoel-Gammon, 1985). Early word forms tend to feature reduplication, anterior plosives, nasals and glides and tend to be those that are related to the patterns produced during babbling (Locke, 1989). Oller and Eilers (1982) investigated the vocalisations of 16 one-year-olds learning either Spanish or English. Cross-linguistic comparison of segmental and structural characteristics within words and non-words revealed commonalities, such as a predominance of apical plosives, a preference for CV syllables, a general lack of final consonants and similar vowel frequency distributions.

The similarity seen in the consonants that feature within these early word productions across a wide range of languages has been used as evidence to support the idea that this earliest stage of linguistic development is universal. Alongside his discontinuity hypothesis, Jakobson (1968) theorised that there was a universal order of emergence for the segments produced within first words and that this order was based on typological markedness. Thus, sounds that are widespread in the world's languages are described as unmarked and are acquired earlier. However, within the functionalist frameworks the observed similarity in the first words produced by children from diverse linguistic backgrounds is attributed in part to the anatomical and physiological factors that govern the movement of the child's articulators (Davis and MacNeilage, 1995; MacNeilage, Davis and Matyear, 1997; Kim and Davis, 2015). Davis and MacNeilage (1995) for example, extend their Frame-Content Model (discussed in section 2.3.2 with reference to babbling) to word production and provide

evidence for a biological influence within the structure of the words produced. Furthermore, MacNeilage, Davis and Matyear (1997) present data to illustrate their assertion that changes in lip and tongue position are secondary to oscillation of the jaw.

Evidence for continuity can also be sought from studies investigating oro-facial movements across the two developmental stages. Nip, Green and Marx (2009) conducted a longitudinal study of 24 children, gathering data every three months from 9 to 21 months of age. They measured the speed of jaw and lip movements as the children produced babble and words. Their findings revealed no difference and therefore provide support for the notion of continuity across these developmental stages. First word similarity can also be attributed to the learning mechanism (see section 2.2 for a full description) that pervades this process with the development of implicit and explicit knowledge governing many aspects of this process (Vihman, 2017; Vihman and Kunnari, 2006). At this stage, the child is said to engage in implicit matching of words they are hearing within the speech streams of those around them to patterns that they are already producing within their babble and are therefore phonetically accessible (Vihman and Croft, 2007)

Studies that include words and non-words in their analysis have revealed a number of features characteristic of early stages of speech development. Robb and Bleile (1994) for instance, found that consonants produced in vocalisation-initial position are generally voiced plosives and nasals in the early stages, with voiceless plosives and fricatives appearing a little later. These conclusions were drawn on the basis of longitudinal data from children between the ages of 8 and 25 months, and by not only analysing the patterns found in words, but also in non-words. The inclusion of non-words led to more variety within the consonant inventories compiled, when compared to a similar study carried out by Stoel-Gammon (1985). Vihman, Ferguson and Elbert (1986) also found greater phonetic variation within the non-words produced by the participants of their study, as compared to words. Observing vocal production at a surface level without separating vocalisations by type allows for consideration of speech sound development as a whole.

However, there is often a need to separate words from non-words based on criteria concerned with the apparent purpose of the vocalisation, or lack thereof. To this end, many researchers refer to a set of criteria proposed by Vihman and McCune (1994) when attempting to categorise children's early vocalisations into words and non-words. These criteria are

divided into two types: (1) those referring to the context surrounding the vocalisation, and (2) those associated with its shape. By applying these criteria to each word candidate extracted from the data, researchers make an attempt to be consistent across different children and different data points. The difference between babbling and words does not necessarily lie in the phonetic make-up of the vocalisations. Rather, it lies in when these vocalisations are used, and the relationship between the vocalisation and the referent within the environment.

Alongside these common trends, it is also possible to identify ambient language influence within words produced at this stage. Majorano and D'Odorico (2011) investigated these aspects within the vocalisations of 11 children being exposed to Italian. Data collection involved recording the children between the ages of 0;10 - 2;0 engaged in naturalistic play with their mothers for 30-minute periods, monthly for the first 3 months and bimonthly thereafter. The study explored the relationship between the structure of the children's vocalisations and high frequency syllabic types seen within Italian and found that there was an increasingly strong link between the two from age 0;11 onward with significant increases seen between various data points. In terms of the consonantal make-up of the vocalisations recorded, there seemed to be a high proportion of labials within the earlier recordings which gradually decreased with age until it was in line with frequency values seen within the adult language at age 1;2. The proportion of alveolars also came to be in line with adult language values at this age, although this followed a gradual increase across the data points.

The word production attempts at the single-word stage are also likely to be highly variable. This variability is likely to be a result of a combination of factors such as imprecise movements of the articulators due to underdeveloped motor control and varying word complexity. Sosa and Stoel-Gammon (2006) investigated intra-word variability within the naturalistic productions of four typically developing children between 1;0 and 2;0. A methodology proposed by Ingram (2002) known as *proportion of whole-word variation*, whereby a ratio is calculated based on dividing the number of distinct phonetic forms by the total number of productions of the same word, was used to investigate the longitudinal data collected. These ratios were then converted to percentages which were calculated for each child at each age. Data were collected at three-month intervals and information was also gathered regarding the children's lexical development using the MacArthur-Bates Communicative Developmental Inventory (Fenson *et al.*, 2006). The findings revealed that variability ranged from 17% to 59% with these values being derived from the data of two

different children who were 1;6 and 1;9, respectively. The pattern of variability observed seemed to be unique to each child but despite this, there were some general patterns that could be observed. The authors reported that there was a considerable degree of overall variability even at 2;0. There seemed to be a relationship between the rate at which a child's lexicon was expanding in conjunction with their age and the pattern of variability seen. Children with a large lexicon at a younger age appeared to have a higher degree of variability across their productions whereas those who were older yet had fewer items in their vocabulary demonstrated a lesser degree of variability. Although vocabulary size is also a factor here, this finding seemed to support the notion that maturation of motor control mechanisms underlying the articulators play an important role in the stabilisation of phoneme production and therefore reducing variability.

Exploring the structure of the target words attempted in relation to how frequently particular word shapes appear in the language of the environment has also led to assertions regarding ambient language influence. For example, Khattab and Al-Tamimi (2013) reported on the phonological development of five Lebanese children at the single-word stage of development who were residing in Beirut. Arabic was the main language of the environment, but the authors note that English and French are commonly used alongside Arabic in Lebanon. Longitudinal data were collected and their analysis focused on two different developmental points, the 4-word point (when 4 different word types were produced spontaneously during the session) and the 25-word point (when 25 were produced) with the children's ages ranging between 1;1-1;6 and 1;9-2;2, respectively. Their focus was on the target words that the children attempted and whether their syllabic structure matched the expectations for the language to which the target word belonged. To this end, they separated the words targeted by the children into Arabic, English and French and then separated each category further into mono-, di- and multi-syllable words. They found that the distribution of early word shapes was in line with differences in the frequency of mono- and di-syllables across the three languages, with the majority of Arabic and French words attempted by the children being disyllabic whilst those attempted that could be identified as English were more likely to be monosyllabic. The findings of this study also provided evidence for the influence of geminates on target word selection by children acquiring languages in which they occur. This is a finding that has been supported in further studies investigating the role of geminates in early speech development (Kunnari, Nakai and Vihman, 2001; Vihman and Majorano, 2017; Vihman and Velleman, 2000).

2.3.4 Emergence of a phonological system

Categorical speech perception abilities, as first discovered by Eimas *et al.* (1971) develop early in the first year of life. It can be seen that differences in the patterning of contrasts across the phonetic parameters of each speech sound result in the formation of phonological categories. These appear in accordance with denser clusters of contrasting sounds, with contrasts that children hear that do not fit with this pattern holding less attentional value (Vihman, 2017). Recall from 2.3.3 that early word production is based on representation of whole-word patterns rather than individual segments which seems to be at odds with these sophisticated perception abilities. Vihman (2017) addresses this disparity through a review of the literature and reference to both implicit and explicit learning mechanisms, which when integrated can be referred to as the *complementary systems model* (Lindsay and Gaskell, 2010; McClelland, McNaughton and O'Reilly, 1995).

The focus of the previous section was early word production, and therefore whole-word representation. But as the child's lexicon expands, there is a move towards the creation of a system based on segmental information. The necessary systematisation of this knowledge is done through a process of abstraction, drawing on these different sources to move away from representations being entirely whole-word. What follows is a system containing segmental representations alongside and is more in line with the adult phonological system. This organisation takes place in the context of a great deal of individual variation (Vihman, Ferguson and Elbert, 1986). Awareness of individual variation is at the core of the template-based approach to segmental representation (Vihman and Croft, 2007; see section 2.2 for an overview). The templates employed by the child are borne from the specific motor schemes that have been developed during the pre-speech phase and are therefore individual to them. Furthermore, there is a recognition within this approach that the relationship between the various words within the child's early lexicon is greater than that between the child's production and the adult target being attempted.

The child's very first words are typically relatively accurate copies of the adult words on which they are based, with most of the errors seen being those of omission rather than substitution (Vihman, 2014; section 2.2). The accuracy achieved by the child at this point is down to the matching of their existing abilities with lexical items within the input and the resultant selection of early target words based on this similarity with what they are already

able to produce. Once the child is able to produce a number of these *selected forms* i.e. copies of adult words, the process of abstraction begins. The child begins to apply existing templatic patterns to novel attempts at words. These productions are termed *adapted forms* and are said to signal the emergence of a phonological system (Velleman and Vihman, 2002). See Table 2.1 for an example of words produced by one child, Alice, who was being exposed to English. These word production attempts were attributed to the same templatic pattern, CVCi, and this example illustrates the difference between selected and adapted forms.

Alice (1;2) <CVCi>

Selected		Adapted	
Target word	Child form	Target word	Child form
baby daddy lady mummy	[bebi] [taɟi] [jɛiji] [maɲi]	bottle hiya	[badi, baːtʃi, batji] [haːji]

Table 2.1 Example of selected and adapted forms (Vihman et al.,1994)

Initial accuracy in speech production, as illustrated by a close match between the target words and the children's attempts, is followed by a period of decreased accuracy with the production of many homonyms leading to reduced intelligibility (Vihman, 2009, 2010; Vihman and Croft, 2007; Vihman and Velleman, 2000). This can be conceptualised as overgeneralisation or overuse of production patterns that are familiar to the child and motorically accessible as a result. These production patterns, termed *vocal motor schemes*, mean that advances can be made in terms of extension of the lexicon. However, this extension can come at a cost to overall intelligibility.

Vihman (2014) argues that children use templatic forms to support their ability to produce words at this early stage of speech development, and that the observed variation shows that each child responds differently to the complex task of word production. This has been illustrated through the application of the templatic approach to the word production attempts of children experiencing a range of ambient languages (Vihman, 2010; Vihman and Keren-Portnoy, 2013). Some of the earlier studies discussing the templatic approach tend to feature examples of templatic forms that have been picked out in order to illustrate the concepts being discussed (e.g. Vihman and Croft, 2007; Vihman and Velleman, 1989) without

inclusion of information regarding prevalence of these patterns within the overall sample. Conversely, the procedure followed within Vihman (2010) contains an initial focus on the structural correspondence between the target words and the children's vocal production attempts whereby the prevalence of various word shapes is quantified before moving on to an investigation of the segmental contents of the templates (this is also the case within studies featuring bilingual children (e.g. Khattab and Al-Tamimi, 2013; Vihman, 2016 these are discussed in 2.4.3). Vihman (2010) identified templates in the vocal productions of 33 children, with a mean age of 1;6, from 6 different languages: English, Finnish, French, Italian, Estonian, Welsh. Taking data from various studies where longitudinal data had been collected, a single session towards the end of the single word period was chosen to undergo a systematic search for templates. Analysis revealed substantial commonalities in the children's productions as well as variability in the way templates were created and applied. For example, the presence of coda consonants varied across the different language environments, being a predominant pattern for the children from Welsh environments whilst being absent from the templates of children being exposed to French. There was also evidence of patterns that are generally thought to require a high level of motoric control, for example, templates identified within the Welsh and English samples containing fricatives and a French template containing a word-medial lateral.

There is evidence that some of the variation we see within the templates created and applied by children is related to language-specific aspects of the language(s) of the environment. Vihman and Croft (2007) present various examples that illustrate this effect, one of which being discussion of the 'no onset' template across the different language environments recorded: English, Welsh, Finnish, Estonian, French. A tendency to omit word-initial consonants within early word production is particularly interesting due to the assertion put forward by traditional markedness theorists that CV syllables would be favoured as they are arguably the most widely occurring. It is argued within this framework, however, that in some languages, prosodic patterns lead to greater salience of word-medial segments giving rise to the use of no-onset templates within the children's productions. Their findings revealed that there was a far lower proportion of English words adapted to fit a no-onset template than those seen for Welsh, Finnish, Estonian and French. Reasons were given based on differing stress patterns in French with an iambic stress pattern being more widespread. Where languages have a trochaic stress pattern similar to English, the authors proposed that the presence of lengthened medial consonants and shorter initial vowels, as in Finnish due to

gemination and in Welsh due to accent, could be the reason for an increase in salience for the medial portion of the word.

This initial stage of phonological organisation, which is characterised by the existence of templates, is followed by a reduction in template use as the child becomes better equipped to produce the range of words and phrases needed to successfully convey meaning. At this point, there is a move towards a more systematic relationship between adult and child forms which is illustrated by the prevalence of segmental substitutions (discussed further in section 2.5.1).

Section 2.3 has provided an overview of early speech development in children. In turn, the following developmental stages have been introduced: perception, pre-speech, first words and the emergence of the phonological system, with a focus of the biological and linguistic factors which influence the nature of the abilities learnt by children as they move through these stages. This has provided the basis for the next section, where the focus moves to bilingual speech development.

2.4 Early speech development in the presence of two languages

The discussion thus far has been focused on early speech production in the presence of one language. Children learning to produce recognisable speech in the presence of two languages are faced with similar challenges. Nevertheless, there are additional challenges and factors to consider due to the need to differentiate between the two languages they are hearing and develop parallel skills in relation to two languages instead of one. For example, it is likely that they will need to develop motor programmes so they can articulate a greater range of sounds. They will also need to learn to produce more contrasts so that they are able to signal meaning and be understood by others within each of their languages.

This section will begin with a discussion of the task facing bilingual children as they learn to produce recognisable speech in two languages, including the extent to which the two codes are differentiated in perception and production. Then, the nature of the bilingual experience will be considered with the purpose of exploring the context in which bilingual speech development takes place. The final sub-section will focus on the way in which bilingual children develop their phonological system or systems. Much of the literature related to the

topic of bilingual speech development contains comparisons between monolingual and bilingual children. Due to its relevance to the discussion of assessing speech development, these studies are reviewed later in the chapter, within section 2.5.3.

2.4.1 Learning to speak two languages

For a child to be able to receive the two codes that exist within their bilingual environment, they must learn to differentiate between them. Studies focusing on speech perception, specifically discrimination abilities of young children, have amassed evidence that children are able to recognise distinctions, both segmental and suprasegmental, between languages in the first year of life (Byers-Heinlein and Fennell, 2014; Byers-Heinlein, Burns and Werker, 2010; Grosjean and Byers-Heinlein, 2018; Molnar, Gervain and Carreiras, 2014). Byers-Heinlein, Burns and Werker (2010) investigated the language discrimination abilities of newborn babies who had different language experiences prenatally due to different patterns of maternal language use. This study involved investigation of the abilities of babies born to monolingual English-speaking mothers and compared them to those of babies born to bilingual English-Tagalog speakers. Findings indicated that prenatal language exposure meant that both groups were able to distinguish between English and Tagalog. The babies with monolingual English exposure were able to distinguish between their native language and the unfamiliar language, Tagalog. This is in line with what has already been discussed in section 2.3.1 regarding a child's ability to distinguish their native language from unfamiliar languages soon after birth (e.g. Moon, Cooper and Fifer, 1993). However, the babies that had been exposed to both English and Tagalog whilst in the womb were able to discriminate between the two languages, indicating that they had begun to separate the speech stream they were hearing according to language-specific characteristics.

The nature of the bilingual experience (discussed further in section 2.4.2, below) influences the way in which children learn to differentiate between the languages they are hearing. The specific properties of the pair of languages involved, termed language-internal factors (Kehoe and Havy, 2019), lead to various mechanisms being employed as differentiation takes place, alongside a different trajectory in learning the necessary skills. Characteristics such as word order (Gervain and Werker, 2013) and lexical stress (Bijeljac-Babic *et al.*, 2012) have been shown to influence a child's ability to differentiate the languages. Furthermore, languages

with sound systems that contain close phonemic contrasts are more difficult to discriminate (Byers-Heinlein and Fennell, 2014; Molnar, Gervain and Carreiras, 2014).

Studies focusing on speech production rather than perception have also found evidence of language differentiation, which has been illustrated through a number of measures, including those focusing on pre-speech and various aspects of word production (e.g. Andruski, Casielles and Nathan, 2014; Brulard and Carr, 2003; Fabiano-Smith and Barlow, 2010; Poulin-Dubois and Goodz, 2001). Pre-speech vocalisations produced by children experiencing dual-language exposure have also been subject to close inspection, with findings being mixed in terms of language differentiation and interaction. Poulin-Dubois and Goodz (2001) examined the distribution of consonants in the babbling productions of 13 one-year-old children raised in a bilingual French-English environment. They found that the children were producing babble which contained similar consonant distributions in both English and French contexts and therefore concluded that productions were not being modified based on the language of the environment. Conversely, Andruski, Casielles and Nathan (2014) investigated the babbling patterns of a child being raised in a bilingual Spanish-English household while he was interacting in separate language environments. They analysed data at two age points, 30 days apart, when the child was 12 and 13 months old. There were segmental differences with a preponderance of plosives produced in the English context in contrast to a preponderance of fricatives produced in the Spanish context. These studies demonstrate that there is some evidence to suggest that the babbling patterns produced by children hearing two languages at home reflect the language of the environment vocalisation but that this differentiation is not apparent within all studies of this type.

Following the assertion that bilinguals possess two separate systems that interact through the study of syntactic development (Paradis and Genesee, 1996), Paradis (2001) went on to explore whether the same held true for phonological development. Her study aimed to explore whether bilingual two-year-olds had separate systems and if so, what the relationship was between these systems. To this end, four syllable nonsense words that conformed to the phonotactic constraints of either French or English were presented to children who had been exposed to English and French from birth. For each language, 18 monolingual and 17 bilingual children were encouraged to repeat the nonsense words whilst engaged in structured play activities within each of the language environments. Comparison of their responses showed that the bilingual children adhered to the word and syllable structure of the language

of the environment when repeating multisyllabic nonsense words, thus lending support to the notion of language differentiation within the phonological systems of bilingual two-year-olds. Similarity with monolingual peers in terms of the simplification patterns used whilst attempting these polysyllabic nonsense words led the author to conclude that the bilingual children possessed a separate system for each of the languages they were learning. However, there were specific differences found in the preservation of syllables by the bilingual children as the words were truncated, suggesting influence of word stress patterns from their other language. Differences seen in the speech production behaviours of monolingual and bilingual children who are learning the same language suggests that presence of two systems leads to a different developmental trajectory. A key outcome of this study was the notion that bilingual children possess two separate, yet non-autonomous systems, termed the *interactional dual systems model* (Paradis, 2001).

Cross-linguistic differences in voice onset time have also been investigated with the aim of providing evidence for language differentiation. For example, Mayr and Montanari (2015) demonstrated that multilingual children vary the specific nature of plosive production in accordance with language-specific requirements. They used acoustic analysis to examine the speech production behaviours of two trilingual sisters, aged between 6 and 8 years, as they participated in a reading task in each of their three languages, Italian, Spanish and English. Findings revealed a high degree of differentiation across languages for both children, thus providing evidence of separation across languages. The patterns observed, however, were complex and seemingly related to the different input patterns that had made up the children's language histories, with Spanish having been spoken to them by one person only whilst there had been more variety in their exposure to English and Italian. This study demonstrates that close investigation of segmental phenomena can also lead to the identification of cross-linguistic differentiation. It also emphasises the need to explore possible differences in language experience as a factor that can influence patterns seen within speech production behaviours.

The use of other segmental features has been compared across bilingual children's languages. For example, Khattab (2002) investigated the use of the lateral approximant /l/ by English-Arabic bilinguals, aged between 5 and 10 years. With a focus on sociophonetic variation within the input they were receiving and the patterns of production recorded within their data, the study showed that there was a different distribution of clear and dark /l/s seen as words

were produced in different language environments, demonstrating that the children were able to differentiate their languages in production. Some interaction was seen, but this was only when children were using mixed utterances and therefore described to be in the bilingual mode (Grosjean, 2001).

Identification of different phonological error patterns in each of the languages being learned can provide evidence for language differentiation (Brulard and Carr, 2003; Holm and Dodd, 1999b; Holm *et al.*, 1999; Prezas, Hodson and Schommer-Aikins, 2014). Holm and Dodd's (1999b) longitudinal study of two successive bilinguals, for example, revealed different error patterns in the children's first language, Cantonese, which they heard at home from birth and English, which they only heard after their second birthday within a day care setting. Thus, one of the children, Max, fronted his velars and nasals in Cantonese, but not in English. Separation between languages is also demonstrated by Max's different pattern of phoneme acquisition with shared phonemes emerging in Cantonese before English. Holm *et al.* (1999) examined the speech patterns of children who were experiencing either Punjabi, Mirpuri or Urdu within the home and English within a school environment. They also found evidence of phonological processes being used in one language and not the other, for example one child demonstrated weak syllable deletion, stopping and backing among others in Urdu while demonstrating stopping, final consonant deletion, cluster reduction and gliding in English. This study also showed that where processes were apparent in both languages, they appeared at a different frequency with voicing and aspiration errors being far more common in the non-English language.

Prezas, Hodson and Schommer-Aikins (2014) investigated the phonological patterns of 56 typically-development 4- and 5-year-olds who were learning Spanish and English. An analysis of their phonological development across their languages revealed no significant differences. There was, however, evidence of cross-linguistic interaction in terms of the substitution patterns seen, with language-specific segments being produced in the other language. There was also evidence for deceleration when the overall scores for phonological accuracy were compared to data gathered from monolingual participants from previous studies, and the bilingual children were seen to have lower scores.

Where phonological development takes place in the presence of two languages, there is a need to consider the universals of phonological acquisition. Recall from 2.3.3 and 2.3.4 that

these involve biological and linguistic factors. The nature of a child's vocal behaviours during production of pre-speech and early words is heavily influenced by anatomical and physiological constraints. Furthermore, the statistical and declarative learning mechanisms that underlie the development of phonological knowledge mean that all children regardless of the language or languages they are hearing amass the same implicit and explicit knowledge when it comes to the emerging phonology. Within a bilingual context, these processes are taking place in response to stimulus belonging to two separate linguistic codes. But as these are happening within the same individual, they cannot occur in isolation. This results in synchronic transfer between the systems in relation to segments, phonotactic patterns or prosodic features (Morris, 2021).

2.4.2 Experiencing a bilingual environment

Hearing two languages within the home from birth is known as *simultaneous* bilingualism, also termed *bilingual first language acquisition* (De Houwer, 2009). Whilst this is the arrangement that features widely in research into childhood bilingualism, most children who go on to develop the ability to speak two languages will experience one language within their home (termed their *first language* or *mother-tongue*) and another within the wider society and education. This type of bilingualism is termed *sequential* or *successive* bilingualism (Paradis, 2007).

The proportion of time spent hearing and using each language influences the rate and nature of development as does the age at which the bilingual experience begins. This has been found to be true for grammatical and lexical abilities (e.g. Bedore *et al.*, 2012; De Houwer, 2007; Gathercole and Thomas, 2009). The development of speech production abilities depends on repeated exposure to language within the environment, as discussed in 2.3.3. For children to learn to effectively convey meaning through speech production, they need to gather sufficient experience of the relevant structures. Children must become attuned to the regularities they are hearing in the speech of those around them (Vihman, 2002; Vihman, 2017), and in the bilingual context, this needs to happen for two languages.

Many studies have found that the rate of speech development is influenced by use patterns and relative abilities across the languages (Gildersleeve-Neumann *et al.*, 2008; Mayr, Howells and Lewis, 2015; Munro *et al.*, 2005; Goldstein *et al.*, 2010; Montanari *et al.*, 2014;

Keffala *et al.*, 2020). Goldstein *et al.* (2010) investigated segmental accuracy within single-word and narrative samples produced by 50 bilingual children that were grouped for comparison based on patterns of language use. Following the completion of an extensive language use questionnaire by the parents, children were grouped according to frequency of input and output in each language. Segmental accuracy measures were employed and significant differences between the groups suggested that segmental accuracy was related to language use patterns. The relationship between language abilities and segmental accuracy was explored further within this study through direct measurement of language ability via Mean Length of Utterance for words (Ingram, 2002). This was not found to be as strong a predictor for segmental accuracy as parental reports. Conversely, Goldstein, Fabiano and Washington (2005) found no effect of language use when they compared segmental accuracy in bilinguals with those experiencing a predominantly single-language environment (see 2.5.3 for further discussion of this study in the context of comparisons between monolingual and bilingual children).

Children's speech development has also been compared to their vocabulary abilities in each language. Keffala *et al.* (2020) investigated segmental accuracy and vocabulary abilities in 695 Spanish-English bilingual children aged 3;0-6;5. They found vocabulary abilities within each language to be predictive of consonant accuracy. This relates to discussions surrounding the relationship between lexical and phonological development (Sosa and Stoel-Gammon, 2012; Stoel-Gammon, 2011).

The timing of the introduction to the new language also has a bearing on the trajectory of development. Ruiz-Felter *et al.* (2016) investigated phonological accuracy in 91 Spanish-English bilingual children with a mean age of 5;6 and made comparisons based on their age of first exposure to English, as well as their current patterns of language use. Bilingual children who had experienced simultaneous exposure to each of the languages were compared to those where the exposure to each language had been sequential. No significant difference between the groups was identified, indicating that the exposure pattern was not a predictor of increased segmental accuracy. The converse was found when groups with varying degrees of language use in each language were compared, with children who were hearing and using the language in question to a greater degree at the time of the study showing greater accuracy in word production. It seems that the effect of age of exposure on speech development is more pertinent when the first experience of a language is later. Yeni-

Komshian, Flege and Liu (2000), for example, found differences between Korean-English bilinguals who had been exposed to English before and after the age of five.

While greater and earlier exposure to a language can support phonological development, children who spend some of the time receiving input in another language do not necessarily lag behind in the development of that language. For some bilinguals, developing skills in language A actually facilitates the learning of skills in language B. For example, Goldstein, Fabiano and Washington (2005) found that for children learning English and Spanish sounds which were shared between the languages showed increased accuracy as compared to unshared sounds. Montanari, Mayr & Subrahmanyam (2018) gathered longitudinal data from 35 Spanish-English bilingual preschool children. They analysed single word production and investigated segmental accuracy and frequency of error patterns, making comparisons across languages and over time. Their findings revealed that accuracy improved and error rates decreased in both languages over time, especially with regards to shared sounds. This offers support for the notion that information within the input that is presented frequently and with reliability will develop at a faster rate (MacWhinney, 2005). Further studies providing evidence for acceleration effects are discussed in 2.5.3 below.

The amount of time spent in each language is not the only factor that affects the rate and nature of speech and language development. It is also influenced by the quality of the input, by whom it is provided, and the subsequent use of both languages within the home. De Houwer (2007) questioned the effectiveness of the 'one parent, one language' strategy within a minority language setting. Where languages were separated in the home according to person, only one parent spoke the majority language which meant it was difficult to ensure sufficient input from that language. Attempting to keep the languages separate often meant a reduction in home language use. This seemed to be particularly pertinent in minority language settings as the home language was not being supported within the wider society. These findings led to an alternative view of how to facilitate bilingual language acquisition where both parents were encouraged to use the home language as much as possible, with a reduced focus on separation.

Bilingual experience is individual to the child and will also depend on the way in which each of the languages they experience exists within their community and the wider society. There are many bilingual contexts where one of the languages being learnt is the majority language,

and is therefore spoken widely, whilst the other language is spoken by a group of people who are in the minority (Paradis, 2007), including the situation in North Wales. As a result of colonialization, there was widespread adoption of English within Wales. This resulted in a partial language shift, which has meant that there are no longer any monolingual speakers of Welsh. Welsh exists within a bilingual society with much variation across the different regions of Wales in terms of the numbers of Welsh-English bilinguals. In Gwynedd, children would come across the language during many interactions that take place outside of the home due to Welsh speakers being in a majority and as such Welsh being the community language (Welsh Government, 2021). But English would be heard in the wider society also, as well as being the predominant language of the media. Gathercole and Thomas (2009) demonstrated that vocabulary development is uneven across Welsh and English in children experiencing various home language settings. Children were found to acquire vocabulary and several grammatical aspects in Welsh under particular conditions. This was in contrast to their acquisition of English which was seen to take place regardless of home language patterns. They related their findings, in part, to societal differences between Welsh and English.

Where bilingual speakers exist within societies, there exist various patterns of language use. The status of the language and density of speaker numbers has a bearing on how widespread the use of each language is, with language choice often being demarcated by the context of the interaction, e.g. family, religion, education. This leads to a range of environments where the two languages exist, and where languages exist in contact, the child is faced with the task of differentiating the two languages within the speech of others heard within the wider society (Grech and Dodd, 2008).

Language contact over time can lead to substrate effects, where the phonetic and phonological make-up of a language is influenced by that of another language (Sankoff, 2002; Sankoff, 2001). Prolonged use of the language by bilingual speakers means that new varieties emerge that contain characteristics of the other language, an example of this is Welsh English (Penhallurick, 2004; Wells, 1982). In this context, English was historically adopted which resulted in mass L2 acquisition. Similarities can develop as a result of language contact, a process known as convergence (Bullock and Gerfen, 2004; Matras, 2020). Transfer from Welsh to English during the partial language shift resulted in both segmental and structural convergence (Morris, 2013). The degree of influence of Welsh on the English spoken in an area is thought to be dependent on the history of language contact in

that area with areas where there is a large proportion of Welsh speakers demonstrating greater influence (Morris, 2017; Thomas, 1994).

The production of consonants is largely similar across Welsh and Welsh English, however there are some language-specific patterns especially in relation to approximants. Morris (2013) examined the realisation of /l/ and /r/ across Welsh and English in bilinguals residing in two towns in North Wales: Mold and Caernarfon in order to explore the effect of home language, gender and geographical factors. This study found evidence for convergence as well as variation. For example, the production of /l/ across both languages was found to correspond to the dark category providing evidence for phonological convergence. However, detailed analysis showed that there was phonetic variation across Welsh and English with Welsh realisations being darker, especially for females.

Welsh and Welsh English have been compared on the basis of structural properties also, through comparison of the realisation of lexical stress (Mennen *et al.*, 2020). Mennen *et al.* (2020) investigated the production of Welsh and English disyllabic words where stress was on the penultimate syllable in four groups of men representing different types of linguistic experience. The findings revealed convergence across Welsh and English in terms of how lexical stress was realised, and this was true for most of the measures implemented. However, cross-linguistic differences were also found in relation to intensity ratio and unstressed vowel duration.

Bilingual speakers will use different *language modes* depending on the language background of their interlocutor (Grosjean, 2001). Whilst interacting in one of their languages with a monolingual speaker of that language, they are said to be at, or close, to a monolingual language mode. Their other language is thought to be deactivated as much as possible, albeit never entirely, to avoid possible negative consequences of linguistic interactions, such as using a word from that language that is not understood, leading to communication breakdown. However, when bilingual speakers interact with other speakers who share their knowledge of both languages, they are described as entering a bilingual language mode with both languages active and therefore both being utilised as part of the interaction. This can result in *code-switching* where alternation occurs between the languages or elements of both languages are used within the interaction (Myers-Scotton, 2005). For Welsh-English bilinguals, code-switching often takes the form of insertion of English nouns, adjectives,

verbs and participles into utterances that are otherwise Welsh (Deuchar, 2005). Subtle phonetic changes can occur during the production of code-switched words, indicating cross-linguistic influence (e.g. Muldner *et al.*, 2017). This does not only occur across languages but has also been seen in different varieties of English by bilingual children who are being exposed to accentual variation within the input they are hearing. These children become adept at utilising the specific phonetic characteristics of different English varieties to switch from one to another depending on the needs of the situation (Khattab, 2013).

The relevance of code-switching to the discussion of early bilingual speech development is two-fold. Firstly, young children will likely hear utterances that contain both languages as those around them speak, and they must nevertheless learn to differentiate between the two languages (see next section for further discussion of differentiation in young bilinguals). Secondly, as children begin to use their first words, if they are experiencing bilingual input, they are likely to use words from both their languages. Studies have shown that children's word use is related to the language of the environment, with words belonging to the language of the environment occurring at higher proportions than those belonging to other language (Pearson, Fernández and Oller, 1993). Where children have included both languages in one utterance, this has been taken as evidence for a lack of differentiation. However, Quay and Montanari (2016) posit that these conclusions have been drawn due to a largely monolingual perspective of bilingual language development. Taking the view that a bilingual is not the same as two monolinguals in one body, utterances that feature code-switching (often termed *code-mixing* when referring to children where the switch is not deemed to be based on choice) need not be seen as evidence for an undifferentiated system, but rather as a result of not having access to all lexical items in both languages (Genesee, Boivin and Nicoladis, 1996).

2.4.3 Emergence of a bilingual phonological system

Knowledge and skills are accumulated as a result of linguistic experience. Where this experience relates to two different languages, the knowledge gathered relates to two sets of structures and the outcome is that a child is able to draw on either system to support their word production and subsequent expansion of the lexicon within the single-word period.

In viewing speech development from an emergentist perspective, it can be seen that speech production begins before the existence of a system, in the case of production at least (Vihman, 2016). Within the context of bilingualism, the recent consensus is that children possess two separate systems that interact (Paradis, 2001). But if we are saying that the system is built whilst words are uttered and added to developing lexicons, then when does separation take place in production?

There has historically been much debate within the bilingualism literature as to whether a bilingual child possesses a shared system containing both their languages or whether they have separate systems from the start (Volterra and Taeschner, 1978). Part of this debate has to do with mechanisms of differentiation and interaction, as described in the previous section. But within a framework which claims that systems emerge through use, it could be argued that decisions regarding the presence of one system or two are less important. Continuing with the focus on early speech development, and in particular the single-word period, the discussion here should be on the production of early words across the two languages. Application of the templatic approach (Vihman and Croft, 2007; section 2.3.4) to bilingual development provides a useful framework for its study and will therefore form the basis of this discussion.

As with monolingual children, the words produced by bilingual children are related to each other with regards to their structural and segmental content (Brulard and Carr, 2003; Vihman, 2016; Vihman, 2002). The process outlined in section 2.3.4 whereby children match their existing abilities to the speech input they are hearing in order to produce selected forms with relative accuracy is also seen in bilingual speech development (Vihman, 2002). Patterns of speech production seen within these selected forms are more motorically accessible and therefore employed during the production of novel words, leading to the formation of adapted forms. In bilingual development, studies have shown that words from both languages undergo a similar process of adaptation. Recall from 2.3.4 that similar templates are employed by children learning a range of languages, although some language-specific tendencies have been identified (Vihman and Croft, 2007). For bilingual children therefore, it is not surprising that their application of templates across their developing lexicons is similar. There are studies, however, that have provided evidence that individual preferences and tendencies in the way templates are being applied are being shared across the two languages (Vihman, 2016; Vihman, 2002). Vihman (2016) studied the first 10 words

produced by 5 bilingual children, all learning English and another language. She found that words from both languages were being adapted to fit each templatic pattern that was found. This was given as evidence of shared knowledge and lack of separation at this time, with unified production templates being used across both languages. This is in line with the exemplar-based model of emergent phonology (Bybee, 2001; Pierrehumbert, 2001) that is the basis of the study.

2.4.4 Speech development in Welsh-English bilinguals

Children residing in Wales are being exposed to a variety of English known as Welsh English (see section 3.2 for more information) alongside Welsh in varying amounts. Welsh in Wales as a whole is spoken by a minority of people but this is not the case in all geographical locations. Variation in speaker numbers means that 76.4% of people in Gwynedd are able to speak Welsh, whilst only 16.5% of people in Blaenau Gwent are able to speak the language (Welsh Government, 2021). Welsh and English are used in different ways within education also with all primary schools in Gwynedd adopting a Welsh immersion language strategy, which results in all children residing in this county being either simultaneous or successive bilinguals.

As described in 2.3.3 and 2.5.1, the rate and nature of speech development is dependent on a number of factors including individual variation and ambient language effects. Whilst studies involving children acquiring English are widespread, those involving children acquiring Welsh are few in number. Even in cases where Welsh is the language of the home and the predominant language used within the community, it is almost always necessary to consider a child's speech production abilities in both Welsh and English due to the presence of both languages within the community. Munro *et al.* (2005) conducted a cross-sectional study of 83 children who were residing in South Wales, evaluating their phonological development through examination of single-word productions in both Welsh and English. The data gathered allowed for the mapping of a trajectory of development for singleton consonants between 2;6-5;0. This is the only data set reported on to date that provides information on accuracy of singleton consonants produced by Welsh-English bilingual children. The participants were categorised as Welsh-dominant or English-dominant depending on the reported language usage within their homes. The different input patterns did result in different trajectories across the consonants studied.

Within the Munro *et al.* (2005) study, phonological acquisition was defined as 75% of the age cohort producing the consonant with at least 75% accuracy. By this metric, both groups in the youngest age cohort reported, 3;6, had acquired all plosives and nasals in Welsh and English. There was some variation across groups and languages for the acquisition of fricatives and affricates with /f s x h/ acquired in Welsh by both groups, whilst /v/ was acquired in addition by the Welsh dominant group and /ʃ ʤ/ acquired in addition by the English dominant group. In English, both groups acquired /f s h/, with the English dominant group acquiring /z ʃ ʤ/ in addition. For approximants, acquisition in Welsh showed some variability across the groups with the Welsh dominant group acquiring /l w j/ whilst the English dominant group only acquired /l/. Acquisition of approximants in English was the same for both groups, with /l w/ being acquired.

The Munro *et al.* (2005) paper provides information on acquisition based on data collected from children aged 3;0-5;0. Six participants were recruited to the youngest age cohort, 2;6-3;0. All 6 were categorised as Welsh-dominant and data is included pertaining to the mean percentage accuracy score for each consonant, with values given separately for males and females. There was no main effect of gender seen within this study therefore the mean across males and females was calculated giving rise to a list of consonants that had a mean accuracy score higher than 75%. Both groups were producing all plosives and nasals at this level of accuracy and for fricatives, the participants produced /f v s x h/ at more than 75% accuracy in Welsh and /s/ in English at this accuracy level.

A rare account of the single-word period within Welsh-speaking children comes from Bellin (1984) who describes the early productions of his two children and their cousin, all of whom are described as being exposed only to Welsh. The data provided are sparse and taken from a diary-based account but its discussion here is relevant due to the lack of published data on Welsh. Bellin (1984) describes his daughter as having a preference for CV and CVCV word-shapes, whilst his son produced CVC words from the outset of word production. He notes the age of appearance for first words for one of the participants, 11 months, although words were used in a relatively limited capacity at this age. Further attempts to produce adult forms were made by this child from 1;1 with a preference for [d] [p] [b] [g] [l] [w] [m] being

reported within these early forms. Some examples of word attempts are given for the other two participants in the study but the age at which their first words appeared was not included.

The acquisition of consonant clusters in Welsh-English bilingual children has also been the focus of a small number of studies, with data on word-initial clusters reported in Mayr, Jones and Mennen (2014) whilst Mayr, Howells and Lewis (2015) examined word-final clusters. Both studies followed a cross-sectional study design with age cohorts in 6 month increments as well as participants being further grouped in relation to their linguistic experience and categorised as either Welsh- or English-dominant. The word-initial consonants produced by 41 nursery- and primary-aged children were examined with the aim of providing some normative data across seven age cohorts spanning 2;6-6;0 (Mayr, Jones and Mennen, 2014). A 75% accuracy criterion was applied in relation to acquisition of the consonant clusters and the results showed many to be acquired in word-initial position by 3;0 in both languages and across both language dominance groups. These clusters included those that were shared across Welsh and English /bl/, /jl/, /gl/, /kw/, /sd/, /sg/, /sl/ and /sw/ as well as /tl/, /dw/, /kn/ and /gw/ that are specific to Welsh and /tw/ which is specific to English.

Mayr, Howells and Lewis (2015) provided a systematic account of word-final cluster acquisition in Welsh-English bilingual children through the collection of single-word samples from 40 children aged 2;6-5;0. In the same way as the study described above, a 75% correct criterion was applied in order to provide normative data on the acquisition of coda consonants at different ages, along with a depiction of the differences that were apparent across the dominance groups. In Welsh and English, both groups reached the 75% criterion for acquisition for /mp/, /nt/, /nd/ and /ŋk/ by 3;0, the same being true for /ks/, /ns/, /bl/, /ld/, /lx/, /st/, /sk/, /nd/ and /lf/ for the Welsh-dominant group in Welsh and /ps/, /ks/, /sk/, /lk/, /ns/, /ŋks/, /mps/ for the English-dominant group in English.

The findings from these studies highlight the fact that it is not appropriate to apply monolingual normative data to bilingual children as the rate and pattern of development is different to that of monolingual English children (Mayr, Howells and Lewis, 2015). Furthermore, the need to take into account different input patterns when amassing normative data for bilingual children is discussed, given the differences reported in the acquisition of coda consonants when comparing Welsh-dominant and English-dominant bilinguals.

2.5 Assessing speech development and identification of atypicality

Success in the development of phonetic and phonological abilities can be observed and measured in a number of ways. Amongst these, two particularly important ones are segmental measures and whole-word measures.

2.5.1 Measuring early segmental development

Traditionally, measures of segmental acquisition have been called upon to explore the rate of speech development for a given child (Dodd *et al.*, 2003; Scherer *et al.*, 2012; Shriberg *et al.*, 1997). It is important to consider the context in which the child is required to produce the segments (i.e. spontaneous, elicited or imitated) as this may have an effect on the child's speech production. Compilation of a phonetic inventory is one way of establishing the child's ability to produce segments. This can be done without consideration of the function of the child's vocalisation and without attempting to match the vocalisation to a referent. Consequently, a child's vocalisations are recorded and analysed, and credit is given for all segments produced. Production of a wide range of consonants during babbling is seen to be a positive indicator for subsequent speech development (Oller *et al.*, 1999). Vocal practice which contains a wide range of motor sequences will result in the creation of a wide variety of *vocal motor schemes* (VMS) which are integral to the production of first words (Vihman and Croft, 2007). The consonant inventory a child draws on during vocalisation is said to increasingly reflect the language of the environment as a child nears his or her first birthday (Boysson-Bardies, Sagart and Durand, 1984) and the alignment of the consonants produced with those produced during early word production would suggest that children utilise familiar practiced routines when first attempting to convey meaning (Vihman and Velleman, 2000).

Analyses of the segmental characteristics of children's vocalisations have shown that the consonants produced become more varied with regards to place and manner of articulation (Stoel-Gammon, 1985; Robb and Bleile, 1994). This allows for an investigation of phonetic development as speech sound production is not viewed in conjunction with a function within language. Calculating frequency of occurrence of place and manner categories within words and non-words provides insights into a child's speech production abilities, but do not allow for judgements to be made regarding children's ability to use these sounds effectively i.e. their phonemic abilities (Dodd *et al.*, 2005).

Where it is possible to identify a referent within the environment, speech development can be investigated through accuracy measurement, with an expectation that accuracy will increase as a child gets older (Scherer *et al.*, 2012; Shriberg *et al.*, 1997; Williams and Elbert, 2003). Age-related expectations with regards to accurate production of various consonants has led to normative information being compiled that is used to ascertain whether a child's speech development is following the expected trajectory (e.g. Dodd *et al.*, 2003; Mayr, Jones and Mennen, 2014; McIntosh and Dodd, 2008).

Where children are not accurately producing the segments within words, the nature of the error patterns seen can provide information regarding the rate of phonological development. Large cross-sectional studies have been conducted to investigate English speech development and have provided evidence for the emergence and disappearance of patterns in relation to specific ages (Dodd *et al.*, 2003; James, 2001). Based on the Natural Phonology theoretical framework, there are particular error patterns, or phonological processes, that are expected as a child learns to speak English (Grunwell, 1987).

2.5.2 Whole-word measures

A child's ability to produce segments is not the only way to measure or describe their phonological development. There is a broad consensus that early word learning is based on whole word patterns rather than the learning of individual segments (section 2.3.4). Ingram and Ingram (2001) state that children are driven by the production of intelligible words and that they are active participants in the process. To this end, children attempting to reproduce words that they have heard within their environment and learn from their efforts whilst avoiding the production of homonyms by employing compensatory strategies. Phonological development can be measured through calculation of whole word accuracy (Ingram and Ingram, 2001). Here, words that are closely aligned with their targets are considered accurate and increasing accuracy is seen as an indicator of phonological development.

However, viewing children's rate of development in word production through measurement of accuracy alone is insufficient. Ingram (2002) proposed a measure of phonological complexity called *Phonological Mean Length of Utterance* (PMLU). This measure combines segmental accuracy with information about the number of segments within the target word,

i.e. its complexity. The complexity of words attempted by children increases as the child's speech production abilities develop; therefore, a child with a higher overall PMLU would be seen to be exhibiting more advanced phonetic and phonological abilities.

Intelligibility is an external factor which reflects the level of speech development exhibited by the child. For communication to be successful a child must be able to produce words that are understood by others. Ingram and Ingram (2001) recognise that intelligibility is difficult to measure and suggest that the degree of overlap between the child's production and the adult target is one possible method of estimating the intelligibility of a child's word production attempt. To this end, *Proportion of Whole-word Proximity* (PWP) is a measure which compares the PMLU of the child's realisation and the PMLU of the target word as produced by an adult. A higher degree of match would suggest a word that is closer to the adult target and therefore more intelligible (Ingram, 2002).

2.5.3 Comparing speech development in monolingual and bilingual children

Measures of speech development have been used to examine speech development in monolingual and bilingual children. As a bilingual child is not akin to two monolinguals in the same body, the experience of learning two languages influences both the rate and nature of phonological development. There exists a range of recent studies (Fabiano-Smith and Barlow, 2010; Fabiano-Smith and Goldstein, 2010; Goldstein, Fabiano and Washington, 2005; Grech and Dodd, 2008; Kehoe and Havy, 2019; Montanari *et al.*, 2014) that have compared word production in monolingual and bilingual children. Many of these studies have investigated differences in the rate of phonological development across monolinguals and bilinguals with attempts to illustrate the differences in the rate of phonological development across groups through comparison of various phenomena. Paradis (2001) referred to these differences as acceleration or deceleration. They are termed *positive* and *negative transfer* by Goldstein and Bunta (2012).

Firstly, the accuracy in the production of segments within words has been compared, as demonstrated by *percentage consonants correct* (PCC) or *percentage vowels correct* (PVC) within a single-word elicited sample. Goldstein, Fabiano and Washington (2005) compared the rate of speech development in children experiencing single- and dual-language exposure by measuring segmental accuracy and frequency of occurrence of error patterns. Data were

collected from children with a mean age of 5;2 who were predominantly English-speaking, predominantly-Spanish speaking and Spanish-English bilingual. Results showed that there was no significant difference identified between the two groups in term of the rate of speech development. This is not the case for all studies investigating segmental accuracy, however. Montanari *et al*'s (2014) study found lower overall accuracy rates for the bilingual participants of their study when compared with a monolingual sample taken from the literature. This study is based on a sample taken from children with a mean age of 3;10. Other studies investigating segmental accuracy within the speech of monolingual and bilingual children between 3;0-4;0 have also found that monolingual children outperformed the bilingual children who took part (Fabiano-Smith and Goldstein, 2010; Gildersleeve-Neumann *et al.*, 2008).

It is not always the case that studies exploring the speech production accuracy of younger children provide support for deceleration, whilst those focusing on older children provide evidence for acceleration. Kehoe and Havy (2019) investigated the segmental accuracy of French words produced by 40 children aged 2;6 who were residing in Geneva. Within their sample, 17 were monolingual French and 23 were bilingual, having a number of other languages as their L1 and French as their L2. Their study consisted of several measures and comparisons, some of which focused on segmental accuracy. Their findings revealed that the bilingual group outperformed the monolingual group on the global measure of percentage consonants correct and also on some of the specific phonological measures included within the design, namely production of codas and word-initial obstruent-liquid clusters. This study therefore suggests that positive transfer effects (described as acceleration above) can be observed when investigating the speech production behaviours of young children.

Secondly, phonetic inventories have been compared across language environments in terms of their size, complexity and adherence to the ambient language specifications (Fabiano-Smith and Barlow, 2010; Fabiano-Smith and Goldstein, 2010; Gildersleeve-Neumann *et al.*, 2008; Johnson and Lancaster, 1998; Montanari *et al.*, 2014). Montanari *et al.* (2014) explored the level of complexity found within phonological inventories compiled based on accurate use of sounds within words. The findings of this part of the investigation revealed that the inventories exhibited by the Spanish-English pre-schoolers whose targeted exposure to English had begun around a year before data collection, were as complex as those demonstrated by age-matched monolingual peers. Fabiano-Smith and Barlow (2010) is

based on the same data as Fabiano-Smith and Goldstein (2010) but here the authors have also attributed the phonetic inventories compiled to various complexity levels, based on the categorisation suggested by Dinnsen *et al.* (1990). Their findings also revealed that the phonetic inventories compiled were comparable to those exhibited by the monolingual children, both in terms of size and complexity. It can be seen therefore that comparing rate of speech development through exploring the complexity of phonetic inventories does not provide evidence of cross-linguistic interaction.

2.5.4 Atypical speech development

The description of a child's speech as atypical encompasses a wide variety of presenting behaviours and contexts. Consider the ideal language learning environment with ample communication opportunities, the absence of anatomical abnormalities which could impede the correct placement of articulators, together with ears attuned to the required frequencies to hear the speech of others within the environment. Under these circumstances, speech and language development should occur without obstacle. However, as noted in section 2.2 with broad reference to learning mechanisms and in section 2.3.4 with more specific reference to the development of the phonological skills required for successful speech development, the process is complex and has many stages. Accumulation of implicit and explicit knowledge is required, together with the development of fine-tuned perceptual and motor abilities. It is not surprising, therefore, that even in the context of a supportive language learning environment, some children do not develop the required skills for effective speech production.

When a child's speech production behaviours do not match those of typically-developing children across the trajectory (sections 2.5.1 and 2.5.2), their speech development is described as atypical. There are several external factors which can affect the development of speech production abilities, for example hearing impairment (Campbell *et al.*, 2003) or cleft palate (Harding-Bell and Howard, 2011). However, the discussion here will focus on children presenting with a functional speech difficulty of no known origin. Where a child's speech deviates from the norm, they are described as having a speech sound disorder (International Expert Panel on Multilingual Children's Speech, 2012). Their development can be conceptualised in two different ways. If a child's speech production behaviours resemble those usually exhibited by a younger child, they may be described as having a phonological, or speech, *delay* (Leonard, 1992; Williams and Chiat, 1993). A child may have a smaller

phonetic inventory than expected or they may exhibit error patterns reminiscent of a younger child when attempting to produce words. This may or may not be linked to slower vocabulary development overall. However, evidence of idiosyncratic or unusual error patterns, not seen to be part of the developmental path followed by the majority of children may indicate that a child has a phonological *disorder* (Dodd, 2013; Eadie *et al.*, 2015). For example, substitution of all medial consonants with a glottal stop or replacing all consonant clusters with a bilabial fricative are seen to be atypical patterns for children learning English (Leahy and Dodd, 1987).

Children with persistent speech sound disorders experience a range of adverse effects. Not being able to produce intelligible speech can affect their wellbeing and ability to establish and maintain successful peer relationships (McCormack *et al.*, 2010; McLeod, Daniel and Barr, 2013). Speech and literacy development are inextricably linked which means that children with speech difficulties are likely to lag behind their peers on the development of reading and writing skills (Anthony *et al.*, 2011). In order to mitigate these negative consequences, early identification and provision of the appropriate treatment is vital (Eadie *et al.*, 2015).

The production of early words is characterised by inconsistency, or variability as described in discussions of typical development above (Sosa and Stoel-Gammon, 2006; section 2.3.3). Its use as a marker for speech disorder led Holm, Crosbie and Dodd (2007) to assert that the term *variation* should be used when describing speech production patterns characterised by difference within typical development and *inconsistency* should be used when the type and degree of difference within production is deemed to be atypical. When error patterns are numerous and unpredictable, a large number of sounds are affected. This can indicate instability within the phonological system which suggests the presence of a phonological disorder. When observing difference within a child's production of speech sounds, one of the factors which separates disorder from typical development is whether inconsistency is seen across different contexts or within the same context. A study of 409 British children aged 3;0-6;11 years was carried out by Holm, Crosbie and Dodd (2007) and sought to describe and quantify the variation seen within the word production behaviours of children at different ages. The results showed that consistency increased with age and is prevalent in the speech of typically developing children. This led the authors to conclude that inconsistency is an indicator of atypical speech development.

Although each clinical presentation of a phonological difficulty is different due to factors unique to the child's own linguistic experiences and preferences, there are certain commonalties which can be useful when seeking to categorise children according to their surface error patterns. Three major classification systems have been suggested (see Waring and Knight, 2013 for a detailed review): the *Speech Disorders Classification System* (Shriberg *et al.*, 2010), the *Differential Diagnosis* system (Dodd, 2013) and the *Psycholinguistic Framework* (Stackhouse and Wells, 1997).

There are three subgroups common to all classification systems featured: (1) children with difficulties with articulation; (2) children with difficulties in motor planning and programming; and (3) children with phonological difficulties. The subgroup of children with phonological difficulties is large and heterogeneous and Waring and Knight (2013) describe a lack of evidence regarding qualitative differences between children with *phonological delay, consistent atypical phonological disorder* and *inconsistent phonological disorder*. Dodd (2013), however, describes children that produce phonological error patterns expected in the speech of younger children as having phonological delay, children that produce unusual error patterns not occurring within the speech of typically developing children as having consistent atypical phonological disorder, and children with inconsistent speech production in the absence of oro-motor difficulties as having inconsistent phonological disorder. It is clear that these categories have clinical relevance and this system together with the psycholinguistic framework created by Stackhouse and Wells (1997) posit that deficits in the cognitive-linguistic processes that underlie speech production give rise to differences in the way a speech sound disorder manifests.

2.5.5 Atypical speech development in bilinguals

The study of bilingual children who do not follow the expected trajectory for speech development has so far been limited to children over three years old (e.g. Burrows and Goldstein, 2010; Holm and Dodd, 1999a; Yavaş and Marecka, 2014). This is due to a reliance on data from children whose speech development has been identified as protracted or disordered. By the time children reach preschool age, much of their phonological development has already taken place so there is limited scope within the data collected to investigate early word formation and the emergence of the phonological system. This section

aims to provide an account of what is known about the way speech difficulties manifest in children that are faced with the task of learning two languages. In the same way as was done above (section 2.5.4), this section will focus on children exhibiting atypical speech production behaviours in the absence of any known aetiology.

Monolingual children are identified as having a speech delay or disorder through comparison with a representative sample of their peers (section 2.5.4). Children exposed to a common language will exhibit common patterns with regards to production accuracy (segmental and whole-word), error patterns produced when attempting to produce words and the inventory of speech sounds apparent within their vocalisations. Judgements are made regarding rate of development i.e. whether their vocalisations contain as many different phonemes as their peers' and whether they are being utilised in the same way within the phonological system. Judgements are also made regarding the observable error patterns and whether a child's word production behaviours fit the expected pattern within typical development.

Bilingual children demonstrating atypical speech development will produce error patterns that are different from those produced by monolingual children (Dodd, So and Wei, 1996; Holm and Dodd, 1999a; Dodd, Holm and Wei, 1997). However, in a bilingual context it is difficult to discern whether the observed anomalies within their productions are a result of interaction between the two languages or whether they are indicators of deviant speech development. Careful study of speech development in the presence of two languages is needed as the precise nature of the interaction is dependent on phonological and phonotactic characteristics and is therefore unique to each language pair (Fabiano-Smith and Goldstein, 2010; Khattab, 2002; Mayr, Howells and Lewis, 2015).

Interaction between a child's phonological systems can lead to error patterns that appear atypical when compared to monolingual norms but in reality they do not relate to an underlying deficit. This situation is exemplified by Holm *et al.* (1999) who describe a child learning English and Urdu who has been referred for a speech assessment as he is exhibiting error patterns such as backing which would be considered atypical within a monolingual English context. Data from a group of children learning Pakistani heritage languages and English were presented within the same study. Error patterns deemed atypical for a child learning English were indeed common within the speech of the bilingual children. The authors argued that this was due to interaction between the phonological systems of the

languages involved. Studies of error patterns produced by bilingual children allow us to identify which error patterns would be deemed atypical within a particular population (Dodd, Holm and Wei, 1997; Holm *et al.*, 1999)

To this end, Dodd, Holm and Wei (1997) provided data from a Cantonese-English successive bilingual J.L. who at 5;2 years had been exposed to English for two years. Data analysis indicated that both articulation errors and phonological errors were being made. Comparison to monolingual normative data showed that these errors were atypical. However, in contrast to the English-Urdu bilingual described above, when J.L.'s errors were compared to data collected from other successive Cantonese-English bilinguals, it became apparent that his data were also considered atypical within a bilingual context. This led the authors to surmise that J.L. was presenting with a phonological disorder.

In addition to seeking to overcome the challenges regarding the identification of atypical speech development in bilingual children, researchers have also sought to use data gathered from bilingual children presenting with speech difficulties to comment on theoretical assertions prevalent in the literature. Within literature surrounding phonological delay or disorder, questions are often asked regarding the nature of the observed deficits. Research within bilingual populations has shown that the characteristics of atypical speech are present in both languages (Dodd, Holm and Wei, 1997; Dodd, So and Wei, 1996; Holm and Dodd, 1999a). This illustrates that the underlying cause of their difficulties is not language-specific but rather a general deficit related to certain speech production processes (see section 2.2 for discussion of the processes and mechanisms involved in the development of speech production abilities).

Although errors are different across the two languages in many cases, the type of difficulties and therefore the classification for diagnostic purposes according to Dodd's (2011) subgroups would be the same (Dodd, Holm and Wei, 1997; Dodd, So and Wei, 1996; Holm *et al.*, 1999; Ball, Müller and Munro, 2006; Holm and Dodd, 1999a). For example, Holm and Dodd (1999a) study of two children learning English and Italian simultaneously showed that inconsistency was the main feature of one child's speech in both languages while the other child demonstrated delayed phonetic and phonological development in both languages.

Data gathered from bilingual children presenting with speech difficulties provides further support for the notion that two separate systems exist within phonological development. Despite varying degrees of similarity between the phonological systems involved, distinct error patterns have been found in the speech production of children learning the following language combinations: Cantonese-English (Dodd, Holm and Wei, 1997), Italian-English (Holm and Dodd, 1999a) and Mirpuri-English (Holm *et al.*, 1999). For example J.L. (described above), reported in Dodd, Holm and Wei (1997), used different substitution patterns within each language producing /t/ as [k] in Cantonese but not in English. Ball, Müller and Munro (2006) discuss a Welsh-English bilingual child that is described as having a disorder and a restricted phonetic inventory. They are described as having similar error patterns across the two languages, although final consonant deletion is described as occurring in English and not in Welsh.

Investigation of the speech production behaviours of bilingual children presenting with phonological difficulties informs our understanding of the deficits underlying speech development which does not follow the expected trajectory (Hua and Dodd, 2006). Conclusions can be drawn regarding the existence of separate phonological systems and the effect of the nature of a phonological system on the types of developmental errors made (Hua and Dodd, 2006). Furthermore, increased understanding regarding the manifestation of speech sound disorders in bilingual children will go some way in supporting their identification and therefore timely management (Hambly *et al.*, 2013)

2.6 The present study

The aim of this study was to investigate the trajectory of early speech development within a Welsh-English bilingual community. To this end, the vocalisations produced by a small group of children experiencing different home language environments were examined. The literature reviewed in this chapter has suggested that the phonological system is built through use, with a combination of biological and linguistic factors at play. As referential word use begins, children draw on, and extend, implicit and explicit knowledge that they have gained during the pre-linguistic phase (Vihman, 2016; Vihman *et al.*, 1985). Investigating the production of consonants and words during the single-word period, would further our understanding about the nature of the developmental trajectory at this early stage. It would

also allow for conclusions to be drawn regarding cross-linguistic influence in the context of language contact.

The structure and content of the language or languages of the environment is inextricably linked to the vocalisations that are produced by children learning to talk within it. Through between- and within-child cross-linguistic comparison, the role of the ambient language could be identified and examined. This would provide an insight into the structure and content of linguistic knowledge and how it manifests in the consonants and words produced by children embarking on the act of talking for the very first time.

The study of the typical developmental trajectory across multiple children of the same age would allow for the identification of the commonalities that exist within speech production behaviour. Steps within the developmental process could be identified which would, in turn, allow for examination of any deviation from this expected trajectory. This study includes the analysis of consonant and word production across children who are displaying both typical and atypical development. The vocal behaviours under investigation are being shaped by exposure to Welsh, Welsh English or both Welsh English and Welsh. This is the first systematic account of speech development at this age within this population.

Research Questions

- How do phonological systems emerge during the single-word period? (RQ1)
- What is the role of the ambient language in the production of consonants and early words? (RQ2)
- How does identifying the trajectory of speech development in the single word period support the examination of atypicality? (RQ3)

3 Method

3.1 Introduction

This study aimed to investigate speech development during the single-word stage, when a child begins to vocalise with communicative intent. During this period, which is characterised by a large degree of change and individual variation, there is an increase in phonetic ability alongside gathering of implicit and explicit linguistic knowledge leading to the emergence of the phonological system. This study aimed to investigate the vocal production behaviours seen during this developmental stage, with a focus on three main aspects. Firstly, there was a focus on development over time both in terms of phonetic advancement and phonological systematisation. Secondly, there was a focus on bilingual development and therefore an exploration of the role of the ambient language in the vocalisations produced, both in terms of their structure and the segments contained therein. Thirdly, there was a focus on atypical development, given that this study presented a rare opportunity to explore this early period of linguistic development in a child not following the expected developmental trajectory. In order to meet these aims, a longitudinal multiple case-study design was employed to allow for in-depth analysis of the exact nature of the vocalisations produced by a small group of children.

3.2 The linguistic context

Data collection took place in Gwynedd, North Wales with Welsh being the dominant language within the community (Welsh Government, 2021). There are reported to be 3 main dialectal varieties of Welsh – Northern, Midlands and South, with a further distinction being made between East and West leading to a total of 6 sub-categories (Thomas, 2000). With the aim of providing information on the consonants, vowels and prosody occurring within the linguistic environments encountered by the participants of this study, below is a description of the varieties of Welsh and Welsh English spoken in North West Wales.

3.2.1 Northern Welsh

According to Hannahs (2013), there are 29 distinct consonants found in Northern Welsh; these are depicted in Table 3.1. The fricative /z/ and affricates /ʧ ʤ/ are not commonly used in Welsh and appear mainly in English loanwords. Hannahs (2013) states that the voiceless

nasals /m̥/, /n̥/ and /ŋ̊/ appear in instances of mutation but Bell *et al.* (2021, p. 7) argue that where a nasal mutation is applied, what is realised is "a sequence of the nasal in question followed by the glottal /h/". This recent depiction of northern Welsh which is mostly based on the productions of a female participant from the Llŷn Peninsula in the county of Gwynedd. In this account, the fortis and lenis plosives are depicted /pʰ p/, /tʰ t/ and /kʰ k/ with the presence or absence of aspiration indicating the contrast (Bell *et al.*, 2021). Also, the uvular fricative /χ/ which is described by Hannahs (2013) as sometimes being produced with a velar place of articulation is depicted as /x/ by Bell *et al.* (2021).

	Bilabial	Labio-dental	Dental	Alveolar	Post-alveolar	Palatal	Velar	Uvular	Glottal
Plosive	p b			t d			k g		
Nasal	m̥ m			n̥ n			ŋ̊ ŋ		
Trill				r r̥					
Fricative		f v	θ ð	s (z)	ʃ			χ	h
Lateral fricative				ɬ					
Affricate					ʧ ʤ				
Approximant	w					j			
Lateral approximant				l					

Table 3.1 A representative consonant inventory of Northern Welsh (Hannahs, 2013)

All single consonants within the inventory occur in onset position, although some only in cases of mutation. Most consonants occur in all word positions with the exception of /ŋ/, which only occurs word-medially or word-finally apart from in the context of a nasal mutation. Two- and three-member consonant clusters are permissible in Welsh in onset and coda positions (Hannahs, 2013).

Northern Welsh contains 13 monophthongs and 13 diphthongs, as depicted in Table 3.2. The most striking feature of the system is the presence of the close central monophthongs and the central closing diphthongs. Welsh has a highly regular stress pattern with stress generally occurring on the penultimate syllable (Hannahs, 2013; Ball and Williams, 2001). Lexical stress in Welsh is predominantly marked by a lengthening of the post-stress consonant (Williams, 1983, 1985, 1999; Ball and Williams, 2001).

Monophthongs	
Short vowels	ɪ ɨ ʊ ɛ ə ɔ a
Long vowels	iː ɨː uː eː oː aː

Diphthongs	
Front closing	aɪ ɔɪ eɪ ɑɪ ɔɛ
Central closing	aɨ ʊɨ eɨ
Back closing	ɪʊ ɛʊ aʊ ɔʊ ɨʊ

Table 3.2 Vowel system of Northern Welsh (Mayr and Davies, 2011)

3.2.2 Northern Welsh English

Welsh English is a variety of English that has been and continues to be influenced by the phonology of Welsh (Wells, 1982). The nature of Welsh English in the various regions of Wales has been referred to as being related to the process of anglicisation with the Welsh substratum being most apparent in regions not affected by earliest incursions of English (Coupland and Thomas, 1990), one of these being north west Wales. There are few studies which empirically investigate the production of Welsh English amongst the speakers of Wales and there has been a focus on the country's capital, Cardiff and other South East regions e.g. (Mees and Collins, 1999). There have been some studies that have investigated bilingual speakers' production of specific features of Welsh English alongside their production of Welsh (e.g. Morris, 2013; Morris, 2017), with comparisons being made in relation to linguistic background (Mayr *et al.*, 2017; Mennen *et al.*, 2020; Morris, Mayr and Mennen, 2016).

The consonants found in Welsh English are depicted in **Error! Reference source not found.**; Welsh English contains the same consonantal phonemes as in Southern Standard British English (SSBE).

	Bilabial	Labio-dental	Dental	Alveolar	Post-alveolar	Palatal	Velar	Glottal
Plosive	p b			t d			k ɡ	
Nasal	m			n			ŋ	
Fricative		f v	θ ð	s z	ʃ			h
Affricate					ʧ ʤ			
Approximant	w			ɹ		j		
Lateral approximant				l				

Table 3.3 A representative consonant inventory of Welsh English (Wells, 1982)

There are, however, a number of regional variations described by Penhallurick (2008), some of which are relevant here as they are present in the variety of Welsh English spoken in North West Wales:

1. There is strong aspiration of /p, t, k/ in word-initial and word-final positions, which is described as particularly prominent in North Wales, sometimes approaching affrication. This feature is also noted by Coupland and Thomas (1990), who goes on to describe a phenomenon affecting word-medial voiced plosives whereby the lengthening that is commonplace (discussed further below) is accompanied by a pattern of devoicing and aspiration on release.
2. There is dental realisation of the alveolar consonants /t, d, n/, also described as specific to northern Welsh English.
3. There is a tendency to use voiceless [s] instead of /z/ in word-medial and word-final positions.
4. Patterns of velarisation in the production of /l/ are described as being specified by region, with the dark /l/ variant [ɬ] being dominant in all word positions in North Wales, particularly Gwynedd (Morris, 2017).
5. The realisation of /r/ can sometimes be the trilled [r] or a flapped [ɾ] that is present in Welsh, particularly in areas with high numbers of Welsh speakers. Also, post-vocalic /r/ can be produced word-medially and word-finally in the English spoken by residents of north Wales (Morris, 2013; Morris, 2021).

Table 3.4 depicts the vowels of Welsh English as spoken in rural areas noted by Penhallurick (2008) as based on the analysis and description given in David Parry's *A Grammar and Glossary of Conservative Anglo-Welsh Dialects of Rural Wales* (1999).

Monophthongs	
Short vowels	ɪ ɛ a ʌ ɔ ʊ
Long vowels	iː eː ɛː œː aː ɔː oː uː
Unstressed vowels	i ə ɪ

Diphthongs	
Front closing	ai ɔi
Central closing	oə iə
Back closing	ɪu au

Table 3.4 Traditional rural Welsh English vowels (Penhallurick, 2008)

Penhallurick (2008) describes a number of regional variations in the realisation of vowels, some of which are relevant here as they are present in the variety of Welsh English spoken in North West Wales:

1. The LOT vowel in Welsh English is mainly realised as [ɔ] or sometimes [ɒ], but there are instances where elements from this lexical set feature an <a> in the spelling such as ‘quarry’, in which case LOThas [a] realisation.
2. Words that contain the ONE vowel sometimes contain [ɒ] rather than [ʌ], leading to similarity with the words containing LOT. This is particularly true for words featuring <o> in their spelling, such as ‘none’.
3. A “competition between monophthongs and diphthongs” is described in relation to the FACE, STAY, GOAT, SNOW vowels with geographical distribution meaning that the monophthong realisation is more dominant in North Wales (Penhallurick, 2008 p.112).
4. Pharyngealisation, that is contraction of the pharyngeal arches, is described as affecting all except the most open vowels in the traditional Welsh-speaking areas of North West Wales

In addition to noting some of the above as salient features of vowel production in the Welsh English spoken in north Wales, Coupland and Thomas (1990) describe a phenomenon whereby the KIT vowel in stressed monosyllables and the second element of the CHOICE diphthong are produced as a close front vowel e.g. ‘tip’ [tɨp], ‘boy’ [bɔːɨ].

Lexical stress in English is unpredictable and varies across words with the most reliable acoustic correlates being vowel duration, f0 and intensity. This leads to the primary stressed syllables in English having a greater intensity, longer duration and higher pitch than unstressed syllables (Beckman and Edwards, 1994). Lexical stress patterns in Welsh English have not been studied widely. However, a study comparing segment durations of Welsh-English bilinguals from North Wales found that the post-stress consonant was lengthened in Welsh English (Webb, 2011). It was unclear from this study whether this effect was due to synchronic transfer between the systems of the bilingual speakers as there were no data collected from monolingual English speakers of Welsh English. This comparison was made by Mennen *et al.* (2020) who studied lexical stress in both monolingual and bilingual speakers of Welsh English. This study showed that for both groups, Welsh English had a lower average f0 ratio in stressed rather than unstressed syllables than SSBE and a longer post-stress consonant.

3.2.3 Similarities and differences

There are many similarities between Welsh and Welsh English and where the regional variety of Welsh English is spoken in areas of Wales with high numbers of Welsh speakers, the influence of Welsh is often called upon to explain these similarities (Penhallurick, 2008). Many of the features of Welsh English described above in 3.2.2 can be seen as a result of historic language contact between Welsh and English, and hence also occur in the speech of monolingual speakers. At the same time, Welsh features may also arise from synchronic transfer in Welsh-English bilinguals (Mayr et al., 2017; Mennen et al., 2020) . The following features of Welsh English are described to be the clearest indicators of direct transfer from Welsh:

1. Dental realisation of /t, d, n/, which would be alveolar in most other varieties of English (Penhallurick, 2008).
2. Strongly aspirated, and sometimes preaspirated, plosives in word-initial and word-medial positions (Hejná, 2015; Morris and Hejná, 2020).
3. /l/ velarisation in all word positions (Morris, 2017). It has been argued that this feature of northern Welsh English is more likely to be due to the influence of Welsh than other varieties of English (Morris, 2013).
4. Production of the /r/ phoneme whereby in some speakers or Welsh English, the trilled or flapped /r/ is produced in word-initial and word-final positions and /r/ can be present where it would not occur in non-rhotic varieties of English. This has been described as a result of transfer from Welsh in the speech of speakers from Caernarfon, north west Wales (Morris, 2013; Morris, 2021).
5. Lengthened consonants due, in part, to the characterisation of lexical stress in Welsh and Welsh English (Penhallurick, 2008)
6. Monophthong production that could be related to spelling conventions in Welsh leading to differences in the pronunciation of some words in English. Welsh orthography could have impacted on the production of the LOT and ONE vowel, with the former being produced as [a] in words containing <a> within the orthography and the latter being produced as [o] in words where <o> is present (Penhallurick, 2008).
7. The lack of phonemic distinction between English /ə/ and /ʌ/ seemingly as a result of Welsh influence. According to Penhallurick (2008), there is a marked tendency for the STRUT vowel to be raised and centralised, with /ə/ appearing as a common variant. This

could be due to the fact that Welsh does not contain the /ʌ/ phoneme (Penhallurick, 2008).

8. The monophthongisation of many of the English diphthongs could also be attributed to the fact that Welsh does not contain the FACE and STAY diphthongs (Penhallurick, 2008).
9. The pharyngealisation of vowels could be attributed to the presence of the pharyngealised high central vowels of Northern Welsh (Jones, 1984).
10. The lack of a length distinction between the close front vowels is thought to have influenced the production of English close front short vowels in stressed monosyllables featuring the KIT vowel and the second element of the CHOICE diphthong e.g. 'tip' [tɨp], 'boy' [bɔːɨ]. Coupland and Thomas (1990) describe this phenomenon as likely to be a result of influence from the variety of Welsh spoken historically in the area.
11. Characterisation of lexical stress patterns sharing some features with Welsh, namely the presence of the lengthened medial consonant and differences in the intensity ratios of stressed and unstressed vowels (Mennen *et al.*, 2020).

Despite the similarities between Welsh and Welsh English, there are also differences. Welsh contains the fricatives /ɬ/ and /χ/ which can appear in all word positions. There are also differences in the distribution of consonants within words, although a lack of suitable empirical data means that it is not possible to describe and quantify these difficulties (this is discussed further in 4.6.1). Relevant to this study, in which children's production of both words and segments is examined, are the differences in the distribution of word and syllable shapes across the two languages.

3.3 Ethical considerations

Ethical approval for this study was obtained from the CSHS School Research Ethics Committee before recruitment began (ethics reference 2656). One of the most significant ethical considerations was related to the time and effort that needed to be dedicated by the participating families. Due to the longitudinal design of the study, data were collected often and over a substantial period of time. As the data collection sessions were arranged, accommodations were made for working patterns and other commitments. All adult participants signed a written consent form before data collection commenced. The children who took part in the study were too young to supply formal consent so this was given by their

parents on their behalf. Also, once they were old enough to indicate their wishes verbally, their assent was gained at various points during the recording session. A pictorial representation of 'happy' and 'sad' faces was also available, in order for them to indicate their feelings non-verbally if they wished. Due to the young age of the participants, compliance with the data collection procedures was variable (see section 3.5 for more details). On the rare occasions when children became distressed during the recording, parents were given the opportunity to voice their feelings and decide whether they wished to continue with the recording.

Parents were informed that they were able to withdraw from the study at any time during the data collection period, without giving a reason. This option was not undertaken by any of the participant families recruited.

All personal data, including the consent forms, were stored securely within University-managed cloud storage, that could only be accessed by the researcher. The video footage was recorded onto DVD and kept securely within a locked filing cabinet within the University. All audio and video files created were labelled using a coding system and kept separately from any documentation featuring the participants' personal information. To preserve the confidentiality of the participants, pseudonyms were used within any outputs derived from the study.

As indicated in Chapter 1, there was an unexpected outcome to the study that came to light during the data collection period (see section 3.4 for more details) when one child was deemed not to be following the expected developmental trajectory. As the aims of the study were then extended to include a focus on atypical speech development, an amendment was approved by the School Research Ethics Committee (CSHS). Additional consent was then gained from the child's parents to depict his speech and language development as atypical and to discuss it separately from the other participants.

3.4 Participants

Around the time of their first birthday, a total of nine children residing in Gwynedd, North Wales, were recruited to take part in this study. Four of these were recruited through personal contacts and five other families came forward wishing to take part as a result of being

approached during parent and baby groups. The intention was to arrive at a group of participants that reflected typical home language patterns within the area in order to represent the various experiences of children residing in this diverse bilingual community. The duration of the data collection period and the regularity of the data points meant that some scheduled recording sessions could not take place. It was essential to record the children regularly in order to capture the changes that are indicative of this early developmental stage. Consequently, the six participants with the most complete data sets were selected for detailed analysis (see Table 3.5 for a list of participants, section 3.5 for further explanation of the differences in the size of the data sets and section 3.6.1 for details of the data preparation procedures).

Data were collected over a 12-18 month period and during that time, the participants were experiencing varying degrees of bilingual Welsh-English exposure, depending on the particular language input patterns within their homes. Details regarding language background and current practices were recorded at the start of data collection. Based on the amount of input the children were receiving in each language, and in accordance with procedures outlined in Gathercole, Thomas and Hughes (2008), they were assigned to one of three groups: *only Welsh/ Y **G**ymraeg at home* (OWH), *only **E**nglish at home* (OEH) and **b**oth *Welsh and English at home* (WEH). Note that the initial letter of the pseudonyms given to the children was linked to these categories, i.e. G for OWH, E for OEH and B for WEH.

Beca and Ben were assigned to the WEH group as they were each hearing Welsh from their mothers and English from their fathers. In Beca's case, she was also spending two days being looked after by those other than her parents, but this still amounted to three days in Welsh and two days in English with mornings, evenings and weekends featuring a combination of the two languages during her day-to-day family life. Gwen and Gwawr met the criteria for inclusion in the OWH group as they were hearing Welsh from both their parents and there was little English being spoken within the home, except with visitors. In a similar way, Ed and Eve were each only hearing English from their parents with little, if any, use of Welsh within the home. They were therefore assigned to the OEH group. Eve was experiencing a Welsh-medium environment within a nursery that she was attending one day a week but the time spent there amounted to approximately 9.5% of the time she was awake across seven days. This meant that the language input she was receiving was mostly English

and therefore she met the criteria for inclusion in that group, according to the approach developed by Gathercole, Thomas and Hughes (2008).

It was important to capture the dynamic nature of the language use patterns so discussions were had at the start of every recording session and any relevant changes were noted. Changes in work patterns prompted changes in primary caregivers during the week for some of the participants (see appendix A1 for a detailed depiction of the information gathered). For most of the children, the amount of exposure they were getting in Welsh and English stayed constant for the duration of the data collection period. There was a significant change, however, for Ben between 1;0 and 1;3 when the predominant language used in the home during the week changed. During this three-month period, his father who spoke to him in English was the primary caregiver whilst his mother worked full time. Before this and from 1;3 onwards, his mother who spoke to him in Welsh did not work and was therefore at home with Ben during weekdays whilst his father was at work.

All participants were reported to have normal hearing and at the time of recruitment, they were reported not to have experienced any motor or developmental difficulties. For five of the six participants recruited, their speech and language development proceeded as expected for the duration of the data collection period. However, as Ben approached eighteen months, his parents commented on the fact that he was not producing many words. They explained that there was a family history of late talking, with his older brother, his uncle and cousin following a similar pattern. All parents had been informed of the researcher's role as a registered speech and language therapist at the start of the project. The limitations of this role

Group	Name	Mother				Father				Language parents speak to each other	Childcare	
		Spent childhood/ youth	Language status	Language spoken to child	Weekday contact	Spent childhood/ youth	Language status	Language spoken to child	Weekday contact		Language	Days spent
Welsh and English at home (WEH)	Beca	Gwynedd, North Wales	Welsh-English sequential BIL (English L1)	Welsh	2 days	Gwynedd, North Wales	MON English with incidental knowledge of Welsh	English	1 day	English	Welsh	1 day
											English	1 day
	Ben	Gwynedd, North Wales	Welsh-English sequential BIL(Welsh L1)	Welsh	5 days*	Gwynedd, North Wales	Welsh-English sequential BIL (English L1)	English	None*	English	None	
Only Welsh at home (OWH)	Gwawr	Gwynedd, North Wales	Welsh-English sequential BIL (Welsh L1)	Welsh	2 days	Gwynedd, North Wales	Welsh-English sequential BIL (Welsh L1)	Welsh	None	Welsh	Welsh	3 days
	Gwen	Gwynedd, North Wales	Welsh-English sequential BIL (Welsh L1)	Welsh	5 days	Gwynedd, North Wales	Welsh-English simultaneous BIL	Welsh	None	Welsh	None	
Only English at home (OEH)	Ed	Gwynedd, North Wales	MON English with some L2 knowledge of Welsh	English	5 days						None	
	Eve	Manchester, England	MON English	English	4 days	Manchester, England	MON English	English	None	English	Welsh	1 day

Table 3.5 Group and participant information, including summary of language use patterns.

**Except between 1;0 and 1;3 where for the 5 weekdays he would have been hearing English from his father and only Welsh from his mother in the mornings, evenings and weekends. MON is used to indicate monolingual and BIL is used as an abbreviation of bilingual*

in the context of the study had been explained, specifically that the researcher was unable to provide specific advice or opinion related to their child. Consequently, Ben's parents sought advice from their health visitor which led to a referral to audiology and speech and language therapy when he was 2;3. Data collection came to an end before Ben was seen; therefore, the outcome of these referrals was unknown.

3.5 Data collection

Like many that have examined this stage of children's development, this was a longitudinal observational study (Vihman, 2010). Individual naturalistic play sessions were video-recorded to capture the children's vocal production between the ages of 1;1 and 2;6 during interaction with one of their parents. The children's homes were chosen as the location for data collection as a more familiar environment has been seen to result in a higher frequency of vocalisations being produced (Lewedag, Oller and Lynch, 1994). At six-to-eight-week intervals, the children participated in various play activities within a quiet room in their homes for approximately 50 minutes (see Figure 3.1). The items available were chosen by the parent on the day and given the aim of the study, they tended to have a focus on jointly attending and talking. Examples of the activities undertaken were: small word play such as a farm or a train set, pretend play such as putting on a tea party or setting up a shop, or sharing a book or jig-saw together. The decision was taken not to attempt to elicit particular words from the children as the intention was to gain a snapshot of their usual vocal behaviour, whatever that may look like, rather than have a preconceived idea of the types of words the children should be producing. A total of 92 sessions were recorded, which amounted to 67 hours and 40 minutes of footage. The child's age at each session was recorded in years, months and days. At each interval, the intention was to record all of the children but there were times when this was not possible due to unforeseen circumstances, such as illness (see appendix A2 for an overview of the sessions recorded and analysed). This meant that the total number of sessions recorded varied between seven and eleven sessions for the children from single language homes.

For the children experiencing dual language input within the home (group WEH), a separate session with each parent was recorded at each interval. These were recorded on different days and whilst the other parent was absent from the house so that the child could, as far as

possible, be described as operating within a monolingual language mode during the session (Grosjean, 2001). Although the parents described their language use as being either Welsh or English when talking to their child, code-switching was apparent. This mainly consisted of English words being used within Welsh sentences (see section 2.4.2 for discussion of this phenomenon which is common in bilingual talk and indicative of language use patterns within Gwynedd). Data were collected across nine time points for both Beca and Ben, a total of 18 sessions each. Sessions were video recorded in order to capture contextual information as well as the vocalisations produced. In addition, radio microphones were worn by the child and the parent to allow for the recording of high-quality audio data (Khattab and Roberts, 2011). To protect the microphone and allow for the transmitter to be safely stowed, the equipment was placed within a vest worn by the child, a method used in many other studies of this type (e.g. Vihman, 2016; Keren-Portnoy, Majorano and Vihman, 2009; Velleman and Vihman, 2002; Vihman, 2002).

This also meant that the child could move around freely, without being distracted or impeded by the equipment and cables, allowing them to vocalise as they usually would. Placing the vest on the child was, at times, met with resistance and distress. This typically led to the offer of food or a high interest activity, such as painting, for the purpose of distraction. These methods were not always successful and where the distress became prolonged, recording was suspended, or in rare cases abandoned altogether as was the case for Beca's session at 1;7;14.

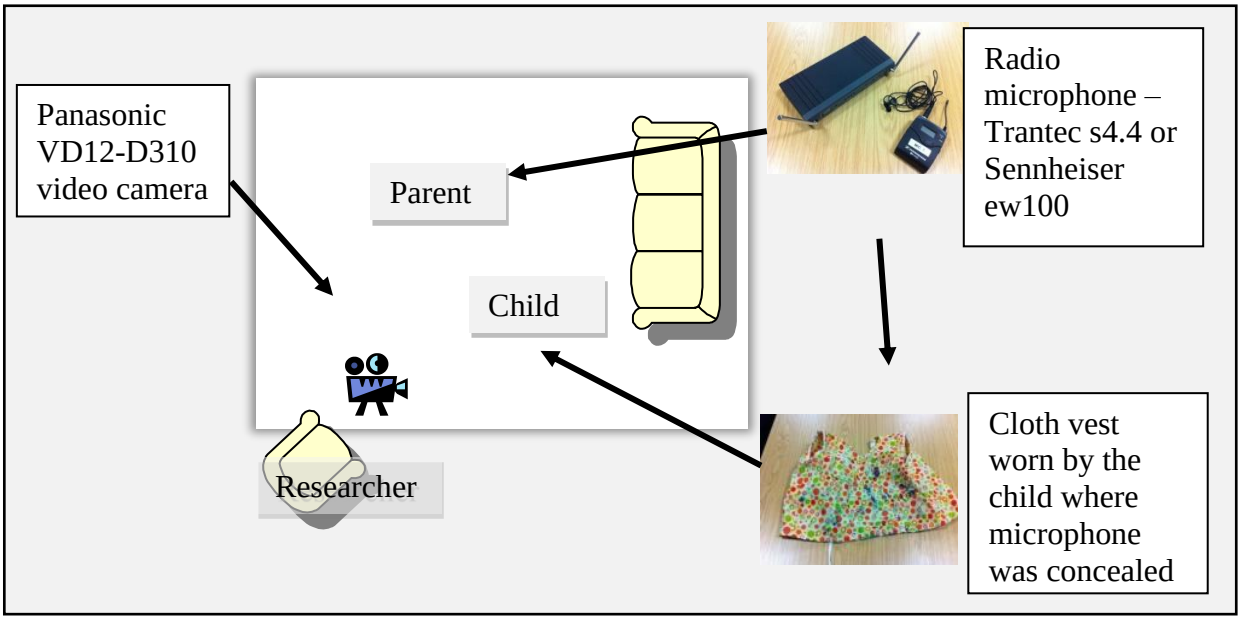


Figure 3.1 Typical layout of people and equipment during a recording session

Whilst the play activities were carried out by the parents, the researcher, a Welsh-English bilingual, took a passive role operating the camera and checking the sound quality using headphones. Once recording had commenced, any attempts made to engage the researcher were met with a polite response matched to the language of the session, and the child was refocused by the parent.

3.6 Data analysis

3.6.1 Data preparation and transcription

The data presented in this thesis comprised thirty-six recorded sessions pertaining to the six participants listed above (see appendix A2 for details of all sessions recorded with an indication of the ones that were chosen for detailed analysis). Thirty continuous minutes of each recording session were selected and subjected to detailed analysis. In the majority of cases, this meant disregarding the first ten minutes and the last ten minutes of what had been recorded. The audio data captured by the microphone worn by the child during this thirty-minute portion was extracted and reviewed. Separate waveform files for each individual vocalisation were then created using PRAAT software (Boersma and Weenink, 2016). A vocalisation was deemed to be any sound or string of sounds produced on a single outward breath (Robb and Bleile, 1994). Vocalisations produced with an ingressive airstream were excluded, as were cries, screams, laughs or those produced when the child's vocal tract was obstructed by a foreign object e.g. when mouthing a toy, drinking from their beaker or eating. Vocalisations that were indiscernible due to environmental factors such as the microphone making contact with the cloth vest, background noise or overlapping speech were also excluded. Each vocalisation was transcribed using symbols from the International Phonetic Alphabet (IPA), with supplementary diacritics and symbols from the extIPA chart (Ball, Howard and Miller, 2018) being utilised where necessary. Each vocalisation was subject to a range of analyses (see sections 3.6.2, 3.6.3 and 3.6.4 below for further details of these). This meant that the audio and video footage was reviewed multiple times on separate occasions. Repeated exposure to the raw data allowed for the transcription process to be verified as well as each stage of the analysis.

Analysis was limited to those sessions where the child was deemed to be within the single-word period. Analysis began with the earliest session that included the production of words. For the majority of the participants, this was the first recorded session where their ages

ranged from 1;1;6 to 1;2;17 and the number of words produced ranged from 3 to10. However, for Ben it was at the second time point, aged 1;4;17, where word production was captured for the first time. Here, he produced three word types whilst interacting with his mother in a Welsh environment. A week earlier, he had been captured with his father, who was interacting with him in English, where none of the vocalisations he had produced were identified as words. Despite the lack of word production, this session remained within the analysed set due to its relation with the Welsh session where it was evident that the single-word period had begun.

Analysis ended with the session where at least 25 word types had been produced within the thirty-minute analysed portion; ages ranged from 1;4;13 to 2;5;19. In a similar manner to that seen within other studies investigating early phonological development (e.g. DePaolis, Vihman and Kunnari, 2008; Kunnari, 2002; Velleman and Vihman, 2002), this was taken to indicate the presence of around fifty words in the child's lexicon, and therefore the end of the single-word period. The intention was to examine 4-6 time points for each child that spanned the single-word period. Variation in the rate of lexical development across the participants meant that the number and spacing of the data points analysed for each child varied, with Ben being the only participant who remained at the single-word stage for the duration of the data collection period. Conversely, Gwen reached the 25-word point just three months after data collection began, with only three sessions available to analyse as a result.

A total of 10,082 vocalisations were identified across all included sessions. Initial analyses included the whole data set, i.e. all vocalisations identified, in order to gain a complete impression of the participants' speech production abilities, regardless of the communicative status of their utterance (Robb and Bleile, 1994). Subsequent analyses included only those vocalisations identified as words which were categorised as such through implementation of the categorisation process outlined in the following section.

3.6.2 Categorisation of vocalisations

This study sought to examine all of the vocalisations produced by the child and not to be limited by those that could be matched to a referent within the environment. However, in order to address the aims of the study, it was necessary to group the vocalisations according to their apparent function within the interaction. Vocalisations were categorised according to

an adapted version of the word identification procedure set out by (Vihman and McCune, 1994). The original procedure that has been widely used by Vihman and colleagues (e.g. McGillion *et al.*, 2017) and others (e.g. Kauschke and Hofmeister, 2002; Lee *et al.*, 2017) involves close inspection of each vocalisation in turn and the allocation of up to 10 points based on context of use and vocalisation shape (see Table 3.6 for details of each of the criteria).

Criteria based on context	Criteria based on vocalisation shape	Relation to other vocalisations
1) Determinative context 2) Parental identification 3) Multiple use 4) Multiple episode	5) Complex match (more than two segments) 6) Exact match (no clear omission, additions or substitutions) 7) Prosodic match	8) Imitated tokens 9) Invariant (all instances with same phonological shape) 10) No inappropriate uses

Table 3.6 Word identification procedure (Vihman and McCune, 1994)

Ahead of assigning points for these specific criteria, the process began with consultation of the video footage so that observations could be made regarding the activity in progress, objects involved, and any relevant non-verbal communication. This led to the creation of two initial categories, 1) 'word candidate' for vocalisations deemed to be produced with communicative intent and 2) 'babbling' for those without communicative intent. Those vocalisations identified as word candidates were allocated points based on the criteria in Table 3.6. This involved matching the vocalisations to referents within the environment, where possible. Given the bilingual context, vocalisations could be matched to Welsh or English referents. As was the case within the original study described by Vihman and McCune (1994), it was not possible to assign word status through reaching a particular score. However, most vocalisations deemed to be words met at least 4 of the 10 criteria. Where it was not possible to identify a likely Welsh or English referent, vocalisations were placed within the 'unidentifiable' category (as seen in Khattab and Al-Tamimi, 2013). For these vocalisations, further application of the word identification procedure was not possible as it involved judging whether there was a match with the target in terms of form and function. Also included within the 'unidentifiable' category were the vocalisations that had originally been assigned a referent but did not meet enough criteria to be given word status (see Figure 3.2).

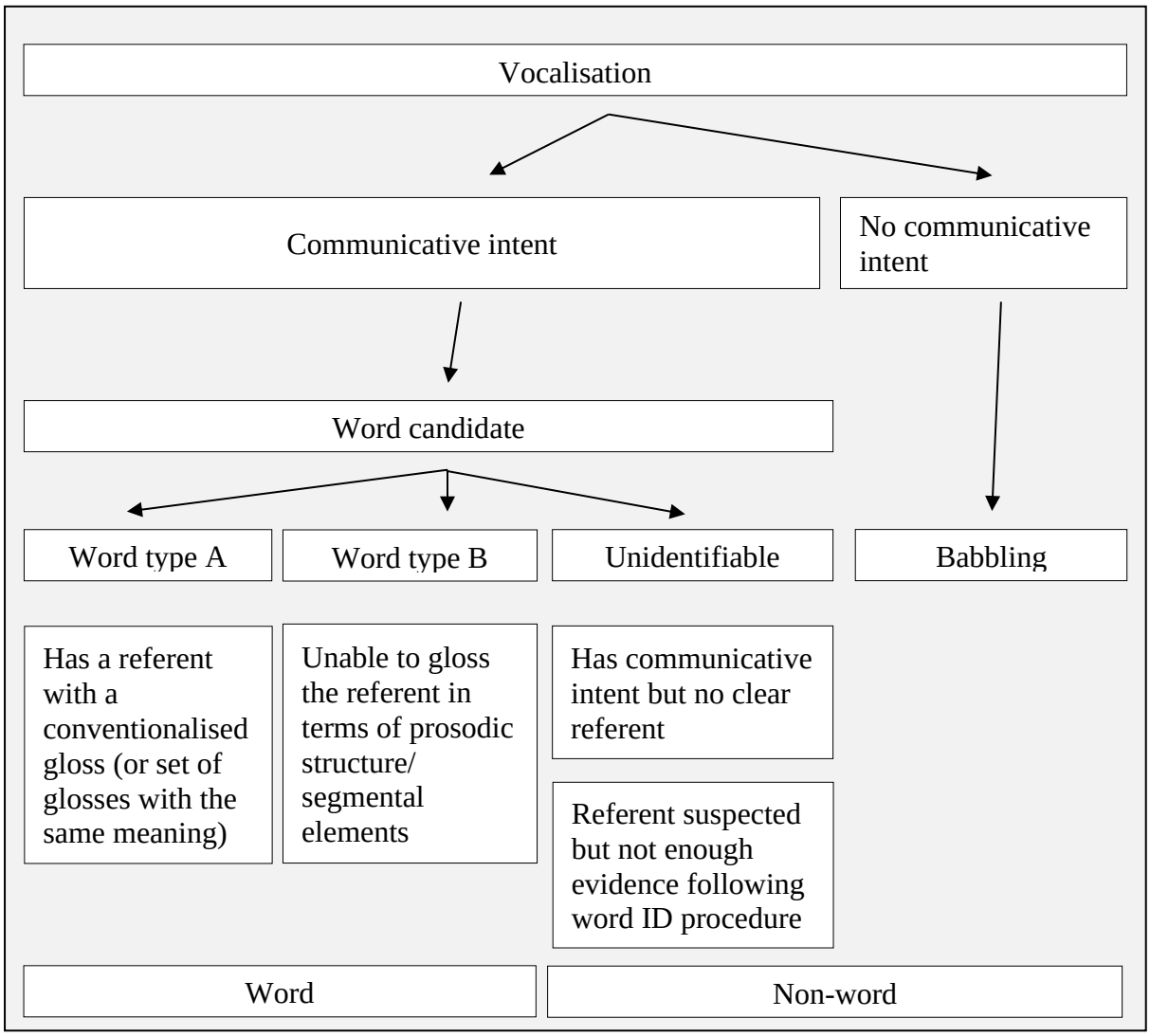


Figure 3.2 Summary of procedure for categorising vocalisations

The remaining vocalisations and their target referents were examined and compared. There were instances where it was not possible to draw on a conventionalised gloss as the child has been attempting to convey an environmental sound (e.g. 'drinking', 'pouring') or an animal sound (e.g.'lion noise'). These vocalisations were grouped within the 'Word type B' category where it was clear that the vocalisation should be given word status as it was recognisable and appropriate to the context but a standard transcription of the target was neither available nor particularly useful. For all cases where there were the same number of syllables within the target word and the child's production, a point for 'prosodic match' was awarded. This prosodic comparison was consistently applied across all vocalisations, thus going beyond the specifications in Vihman and McCune (1994). *Numbers included within these columns relate to the list of 10 criteria set out by Vihman and McCune (1994).

Table 3.7 below illustrates how the various categories were assigned for one child within a single session.

Vocalisation	Proposed target	Contextual information	Criteria based on context*	Criteria based on vocalisation shape*	Relation to other vocalisations	Category assigned
[ɟɪʊx]	milk	As she pours out of the jug into tea cup	1, 2	5, 7	8	Word type A
[kɬ·]	'pouring sound'	During pouring action with jug	1		9, 10	Word type B
[huɟ͡ʝili]	apple	Picture of an apple, Dad asks 'What's this?'	1	7		Unidentifiable

Table 3.7 Example of how the vocalisation categories were assigned, Beca, English environment, 1;5;19.
**Numbers included within these columns relate to the list of 10 criteria set out by Vihman and McCune (1994).*

3.6.3 Consonant Analysis

One of the key areas of exploration within this study is the participants' production of consonants. Vowels were not examined due to the fact that an auditory rather than acoustic method of analysis was employed here, and auditory analyses of vowels were not deemed sufficiently reliable in the context of this study. Consonant inventories were compiled for each of the analysed sessions. In accordance with other studies that involved compilation of consonant inventories (e.g. Fabiano-Smith and Goldstein, 2010; Montanari *et al.*, 2014), all consonants produced at least twice in any vocalisation type were included. This allowed for the size and contents of the inventories to be compared across participants and across languages in line with the aims of the study.

The transcribed vocalisations for each session were inputted into a spreadsheet, and frequency counts for consonants were compiled using SUBSTITUTE and LEN formulae within Microsoft Excel. These formulae allow for quantification of the appearance of a

specific character across a specified range of cells. They were applied to the vocalisation lists for each session, which meant that all occurrences of each phonetic symbol were counted. From this, percentage values were calculated indicating the proportion of consonants produced that belonged to specific place and manner categories. These data allowed for cross-linguistic, between- and within-child differences in consonant production to be identified.

3.6.4 Analysis of word shapes

As described in 3.6.1, the number of word types produced within each thirty-minute session gave an indication of the child's stage of lexical development and was used to monitor their progress through the single-word stage. Following segmental analysis of all vocalisations, those identified as words and matched to a conventionalised gloss were subject to further analyses. Here, the focus was on identifying regularity and irregularity within the structure and content of what was being produced by each child with the aim of illustrating changes over time and ambient language influence.

Word production was investigated both in terms of the target words attempted by each child and the patterns seen during their production, at various stages of development. The templatic approach proposed by Vihman and Croft (2007; see section 2.3.4 for a detailed discussion of this theoretical model) was applied, and in line with many other papers which feature templatic analysis (e.g. Vihman, 2010) there was a focus on both the structural and segmental properties of the children's productions. The procedure for analysis of word shapes was designed to allow for a systematic exploration of the data, leading to identification of templatic patterns alongside illustration of how prevalent they were within the child's productions. This examination centred around three structural properties: syllable number, onset patterns and coda patterns. Similar to procedures followed in Khattab and Al-Tamimi (2013), target words were categorised in terms of the number of syllables they contained and their consonant-vowel configuration with occurrence of different word shapes being compared within and across children and language environments. Regularity was investigated further by examining the ways in which the target words had been modified by the children during their word production attempts. To this end, the correspondence between the structure of the target words and the word production attempts was noted. For example, where syllable number was being investigated, word production attempts made according to

each target word type (i.e. monosyllabic, disyllabic and multisyllabic) were categorised according to syllable number. This allowed for investigation of syllable addition and omission. Supra-segmental comparison of the children's word productions and their targets allowed for differences to be identified and compared across the language environments. In addition, the degree of match to the target with regards to each structural property was calculated for individual sessions, which allowed for systematic comparison of the adult and child forms as well as examination of changes over time.

Following on from this, a detailed investigation of the specific instances where the structure of the child's production attempt was different from that of the target was undertaken. There are various studies that have provided evidence for the presence of templates within the early words produced by children (e.g. Velleman and Vihman, 2002; Vihman, 2016). In the present study, templates were identified within individual samples by systematically comparing children's word production attempts to the target words identified through the implementation of a series of steps. Taking each session in turn, production attempts were sorted according to their word shape with lists being compiled for the three most common consonant-vowel configurations: CV, CVC and CVCV. Within these word shape categories, production attempts were compared to the corresponding target words and labelled as *selected* or *adapted forms* (Velleman and Vihman, 2002; Vihman, 2017; Vihman and Croft, 2007). *Selected forms* were those closely resembling the target word.

Selected form	Adapted forms			
	Syllable addition CVC → CVCV	Syllable omission VCVCV → CVCV	Consonant addition VCV → CVCV	Consonant omission CVCVC → CVCV CCVC → CVCV
'Bella' [bɛlą] 'dada' [dada]	''shoes' [ʃi·tą] [ʃiʂą]	'another' [nuɖa]	'eggy' [hɛgɛ]	'tortoise' [dʑɔji] [tati] 'snail'. [saɪju]

Table 3.8 Example of application of the templatic approach to CVCV word production attempts: Eve, 1;8;21 and 1;9;21, English environment

Attempts that did not match the target word's structure were labelled *adapted forms* and these were categorised further depending on whether syllables or segments had been added or omitted (see Table 3.8 for examples pertaining to the CVCV). The same process was followed for CV, CVC and VCV word production attempts. In this way, the word production

attempts were grouped together which allowed for the identification of segmental commonalities such as consonant harmony or the production of a certain manner category at a particular point within the word shape, e.g. CVC_FV.

There were many instances where the same word had been produced multiple times but the attempts differed in their structure and content. For words attempted three or more times in the same session, the consonantal make-up of the attempts were compared in order to ascertain how many variant forms had been produced. Using an equation taken from Sosa and Stoel-Gammon (2006), a variability ratio was calculated to allow for comparison over time and across different children:

$$\text{Variability ratio} = \frac{\text{Number of variant forms}}{\text{Total tokens}}$$

The number of variant forms was divided by the total number of occurrences analysed for each session giving rise to a score between 0 and 1, with a higher score indicating greater variability. In the examples provided in Table 3.9, a score of 0 was awarded to Gwen's production of 'na fo' /navɔ/ *(there we are)* as there were no variant forms owing to the fact that all three attempts contained the same consonants in the same sequence. Conversely, Eve was given a score of 0.83 (i.e. the number of variant forms was 5, the total number of tokens was 6, so 5/6 = 0.83) indicating a high degree of variability as within her six attempts to produce 'tigger', there were five variant forms as none of the attempts shared the same consonants in the same sequence. The variability ratios for each of the eligible word types were then combined leading to the calculation of the overall variability ratio for the session. As there was no need to compare the child's attempt to the referent gloss, both Type A and Type B words were included in this analysis giving an overall impression of variability for all vocalisations that met the criteria for word status.

Participant	Original form	Variant form 1	Variant form 2	Variant form 3	Variant form 4	Variant form 6
Nel, 1;2;27	hɛja					
Target: 'na fo' /navɔ/	huja					
(there we are)	hɛjaɔ					
Eve, 1;7;3						
Target: 'Tigger' /tɪgə/	tiçid:igą	dikˈdɪgɛ̨	digɛ̨	ʃizɛ	ňdɪgɛ	ðjadəgə

Table 3.9 Words with multiple attempts depicted in relation to calculation of the variability ratio

This chapter has provided an overview of the methods used to collect the required data to investigate the early phonetic and phonological development of six children residing in Gwynedd, North Wales. In what follows, the results from these analyses will be presented. To this end, Chapter 4 will include consideration of the consonants included in the vocalisations produced, with a separation of the consonants produced in non-words and in words. This distinction will lead, in the first instance, to an understanding of the sounds the children are able to produce irrespective of their phonological status. Within Chapter 5, the overall structure of words will be examined, including an analysis of syllabic structure and developmental word shapes. Finally, Chapter 6 will present the case of Ben, the bilingual child with atypical speech development. The chapter will comprise a detailed analysis of his phonetic and phonological development and compare the observed patterns with those of the typically developing children. As such, the data will provide the first account of how speech and a phonological system may emerge when a child does not follow the expected developmental path.

4 The production of consonants in typical development

4.1 Introduction

The results presented in this chapter are based on the vocal productions of five children who were video recorded whilst they engaged in naturalistic play with one of their parents in their own homes. Data collection took place at regular intervals across several months with a total of 26 50-minute sessions being captured from these participants. The children's ages during the first recording session ranged from 1;1;6 (Gwen) to 1;2;17 (Ed). With the aim of investigating phonetic and phonological development during the single-word period of language development, 3-6 sessions that spanned this period were identified for each child and subjected to further analysis. The final session to be analysed was the one that was deemed to represent the 25-word-point, and therefore the end of the single-word period. Due to the individual variation that exists in the rate of lexical development at this early stage, the children's ages during the final session were highly variable, ranging from 1;4;13 (Gwen) to 1;9;21 (Eve). Detailed examination involved extracting all vocalisations that had been produced by the child within a continuous 30-minute portion of the recorded session. For the five children reported on here, this amounted to a total of 6,991 vocalisations being identified, transcribed and subjected to various levels of analysis. The focus of this chapter is the production of segments within typical development. To this end, the range and proportional occurrence of consonants within and across sessions were studied in detail. There were two main variables under observation here: 1) the role of the ambient language 2) the trajectory of phonetic development. In order to examine the data in light of these two parameters, similarities and differences are highlighted, both within each child and across children.

The chapter begins with a report on the number of vocalisations produced by each child in each of the analysed sessions. Consonant production is then explored in terms of the occurrence of manner and place categories with a focus on changes over time and according to the language of the environment. Frequently occurring sounds are then investigated with a small number of those with particularly high occurrence being labelled *preferred sounds.* In the latter part of the chapter, there is a focus on the rate of consonant development with similarities and differences across participants and ambient languages being explored.

4.2 Number of vocalisations

As discussed in 3.6.2, all sounds observed to be produced on a single outward breath were taken together as a single vocalisation (Robb and Bleile, 1994). A word identification procedure (Vihman and McCune, 1994; see section 3.6.2 for further information about how this was applied) was employed to identify those vocalisations that were deemed to have communicative intent and could be matched to a referent within the environment. For each session, the values were collated for the total number of vocalisations and the number identified as having word status (see Table 4.1). Although the intervals between recordings were similar, there was notable variation between the children's ages at each session due to the 6-week range that existed in the children's ages as data collection began. With the aim of applying a degree of uniformity to the data, the child's age during the session was approximated to the nearest month and the individual distribution of data captured across the age range was illustrated.

Age	Beca				Gwen		Gwawr		Eve		Ed	
	Dual language home				Single language home							
	Welsh environment		English environment		Welsh environment				English environment			
	All	Word tokens	All	Word tokens	All	Word tokens	All	Word tokens	All	Word tokens	All	Word tokens
1;1					235	18	110	20				
1;2	201	35	119	20					185	9		
1;3					328	94	117	20	149	13	139	22
1;4	490	77	234	28	514	176	227	66			257	36
1;5									231	44		
1;6	239	47	367	56			316	114			145	43
1;7									197	62		
1;8											282	50
1;9	681	318	584	204					143	68		
1;10									216	108	285	74

Table 4.1 Total number of vocalisations captured per 30-minute session along with number of vocalisations categorised as words

The number of vocalisations produced within the 30-minute session provided an indication of the frequency of vocal production for each child. These vocalisations were interspersed by contributions by their parents as various play activities were undertaken. The number of

word tokens produced by the child within a session gave an indication of the proportion of the vocal attempts that were made with the intention of relaying a message. Examination of Table 4.1 revealed substantial variation in the numbers of vocalisations produced by each child in each session. This variation is apparent throughout the data collection period, with the total number of vocalisations produced in the first analysed session ranging from 110 (Gwawr) to 235 (Gwen) and a range between 216 (Eve) and 681 (Beca, Welsh environment) being seen for the last recorded session. However, despite the variation seen between individual children, there existed a general trend whereby the number of vocalisations and word tokens produced within a given session increased as the children got older and progressed through the single-word period.

It is worth noting here that the portion of the child's day captured for the purposes of analysis may not be indicative of their vocal behaviour in general and that the frequency of vocalisation can be influenced by other factors such as mood, type of activity and amount and type of parental vocal input (Newman, Rowe and Ratner, 2016). This may therefore explain why the values recorded for Beca in the Welsh environment do not follow the general trend of increasing with age. It can be seen within Table 4.1 that Beca produced fewer vocalisations and words at 1;6 than at 1;4. Further evidence that this decrease was due to factors related to that specific recording session can be found by looking at the changes in number of vocalisations produced over time when she was captured in an English environment, where growth is seen from 1;4 to 1;6 to 1;9.

As Beca was captured twice at each age point, cross-linguistic comparisons are possible. However, there does need to be a degree of caution applied when making these comparisons, as the language of the environment was not the only difference between the sessions. Recall from section 3.5 that sessions where the language of the environment was deemed to be Welsh were those where Beca was engaged in play activities with her mother, whereas during the sessions where English was the language of the environment, she was interacting with her father. It has been shown that the type and frequency of vocal behaviour can vary depending on whether children are interacting with their mother or father (Pancsofar and Vernon-Feagans, 2006). Inspection of Beca's data within Table 4.1 revealed a higher number of vocalisations being produced within the Welsh environment, when she was engaged in play with her mother, as compared to the English environment, when her father was the

interlocutor. This observation holds true for all data points except 1;6 where more vocalisations were identified within her English environment session.

4.2.1 Categorisation of sessions according to word stage

Changes in vocal behaviour were examined over time in order to investigate the developmental trajectory during the single-word period. In order to track and compare linguistic development across the data points captured, the number of word types produced in each session was calculated (see Appendix B1 for word lists and Table 4.2 for number of types in each session). This measure of linguistic development, known as *word-stage* or *word-point*, has been widely used in previous research of this type. As described previously in 3.6.1, data analysis came to an end once the *25-word-point* had been reached as this was deemed to indicate the end of the single-word period (DePaolis, Vihman and Kunnari, 2008; Kunnari, 2002; Vihman, 1993; Vihman and Velleman, 2000). As described above, there was variation in the ages at which data were gathered as well as the amount of time taken for a child to reach the 25-word point.

Where between-child comparisons were being made in line with the aims of the study, there was a need to group participants according to their word-stage. Due to the nature of the data collection and the individual differences seen in the nature of the developmental trajectory, it was not possible to match a specific word-stage to the sessions that had been captured. Instead, word-stage categories were formed with the intention of grouping together sessions seen to be at a similar stage, whilst spacing them out at intervals along the trajectory. Where there were two sessions with a similar amount of words produced in each, for example Eve produced 7 word types at 1;2;21 and 6 at 1;3;1, only one of the sessions was included in the group frequency counts and percentages for that word stage. The outcome of this categorisation process was that the 'up to 7' and '8 to 15' categories contained two sessions, Beca and Gwawr, in the Welsh environment and three sessions, Beca, Eve and Ed, in the English environment. The '16 to 24' and '25+' categories contained all three participants in each language.

Number of word types produced in 30-minutes		Up to 7		8 to 15		16 to 24		>25	
		Age	Word types	Age	Word types	Age	Word types	Age	Word types
Welsh environment	Beca	**1;2;1**	5			**1;3;20** 1;5;19	22 18	**1;9;9**	46
	Gwen			**1;1;6**	10	**1;2;27**	24	**1;4;7**	57
	Gwawr	**1;1;7**	3	**1;3;1**	13	**1;4;13**	21	**1;6;1**	30
English environment	Beca	**1;2;4**	5	**1;3;25**	15	**1;5;19**	16	**1;9;9**	31
	Eve	**1;1;21** 1;3;1	7 6	**1;4;28**	8	**1;7;3** 1;8;21	16 19	**1;9;21**	60
	Ed	**1;2;17**	3	**1;3;29** 1;5;17	12 13	**1;8;10**	22	**1;9;11**	33

Table 4.2 Number of word types produced during each session, alongside the age of the child, with an indication of the word-stage category to which they belonged. Sessions included within the group values are marked in black whilst the ones that were disregarded are printed in grey.

4.3 Frequency of consonant production by place and manner

Exploration of the nature of consonant production in children at this early stage in linguistic development began with an investigation into the frequency at which different consonant segments were produced, according to their manner and place of articulation. Both between- and within-child comparisons were made in order to identify patterns and trends. Grouping of sessions according to the language of the environment meant that Beca's data featured in both groups while the data collected from Gwen and Gwawr only featured in the 'Welsh environment' group values and the data collected from Eve and Ed only featured in the 'English environment' group values. Where possible, within each word-stage category (i.e. up to 7, 8 to 15 etc.) one session from each child was included in the group values (see Table 4.2 above for details of the sessions that were included).

Manner and place of articulation categories were compiled from the frequency data that were available for the individual consonants. With the aim of investigating the role of the ambient language in the frequency of occurrence of consonants that belonged to the different

categories, all included sessions for each of the language environments were taken together at first. Then, to further investigate differences across the language environments whilst also taking the time variable into account, the group values were separated according to the word-stage categories as outlined in Table 4.2. This allowed for comparisons to be made across vocalisation type and across the two recorded ambient languages at different points along the developmental trajectory. The frequency of occurrence of consonants belonging to the different manner and place categories identified at the various word-stages, across Welsh and English environments, allowed for exploration of the role of the ambient language in the nature of the consonants produced. Through comparison of these group values, it was possible to comment on general similarities and differences across the different parameters in line with the aims of the study. However, at this age children's speech production behaviours are subject to a large amount of individual difference (Vihman, 2014). In order to investigate the role of individual difference in the group values compiled, all included sessions for a particular child were grouped together and overall occurrence values were compiled for each manner and place category (see appendices B2 and B3). Where these differences were such that their influence on the group values needed to be taken into account, they were presented next.

Grouping of data collected across sessions that share the same ambient language allow for between-child cross-linguistic comparisons to be made. Cross-linguistic comparisons were also made by comparing data collected from one child, Beca, across sessions recorded at the same time-point. Conducting a within-child comparison meant that cross-linguistic similarities and differences could be observed with the aim of examining ambient language influence. As is often found when linguistic progress is compared across a bilingual child's two languages (Fernald, 2013), Beca's linguistic development across the Welsh and English environments was seen to be uneven (see Table 4.2). It could be seen that her rate of development was more rapid in the Welsh environment as more word types were produced within the 30-minute session at an earlier age. This meant that it was not possible to compare her consonant production in the different language environments within each of the word-stage categories. Instead, cross-linguistic comparisons were made at the 'up to 7' stage along with the '>25' stage as for these stages, there were two sessions corresponding to the same age available.

There was also an intention to explore whether different patterns of consonant occurrence were seen within vocalisations that had been labelled as words due to their apparent communicative status. The results are presented within the sub-sections below with manner categories being depicted first and place categories afterwards.

4.3.1 Manner of articulation: Between-child group comparison

Consonants were categorised based on manner of articulation, resulting in 5 manner categories: plosives, nasals, fricatives, affricates and approximants. The relative frequencies of occurrence of consonants belonging to these different manner categories are depicted below with data being grouped according to vocalisation type and language of the environment (see Figure 4.1). There were three main observations made through inspection of this figure. Firstly, the various manners of articulation occurred at different frequencies within the sessions with plosives being the most frequently observed and affricates being the least common. Secondly, the relative frequencies observed when all vocalisations were considered were very similar to those seen within the subset of vocalisations identified as words. Thirdly, the relative proportions of consonant manner categories produced were similar across the Welsh and English environments for nasals, fricatives, affricates and approximants. There was a difference identified for the proportion of plosives, however, with 40% of consonants produced in the Welsh environment belonging to this manner category, as compared to 35% of those produced in the English environment.

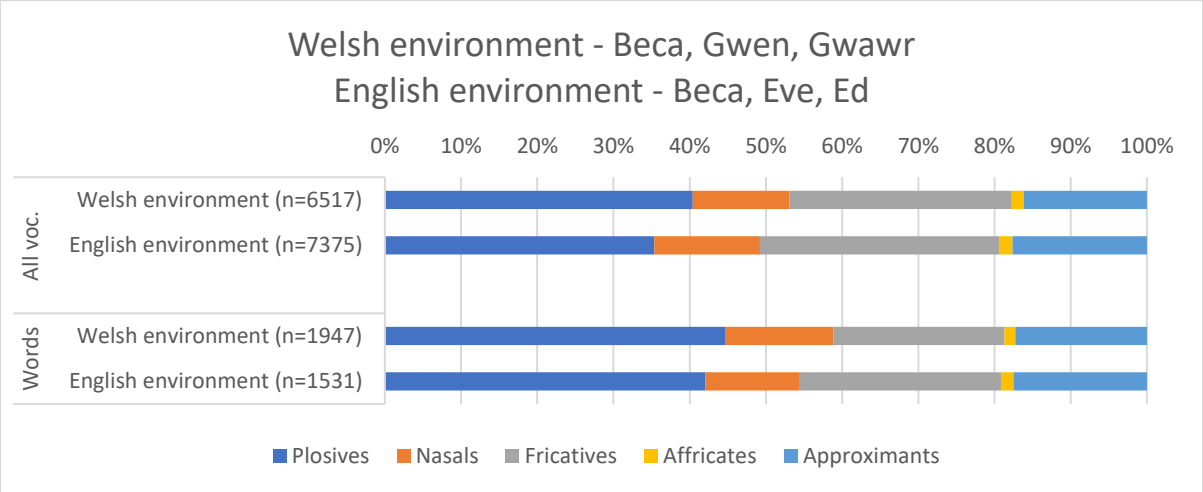


Figure 4.1 Percentage occurrence of consonants according to manner category; comparison of Welsh and English environments for all vocalisations and words only. Total number of consonants produced depicted as n-value.

With the intention of further exploring possible changes in the percentage occurrence of manner categories along the developmental trajectory, these data were further separated according to word-stage category. The results for the Welsh-environment group are depicted in Figure 4.2 with a comparison being made between occurrence within all vocalisations and words only at each word-stage. Inspection of Figure 4.2 revealed that the general trends for the relative frequency of manner categories remained the same across the developmental trajectory. With regards to the comparison between values noted for all vocalisations and the values for words only, for the 'up to 7' and '>25' word-stages, there was little difference with the order of most common to least common manner category staying the same, in line with the general trends seen in Figure 4.1. However, for the '8 to 15' and '16-25' word-stage categories there was a difference between the relative frequency of manner categories in words as compared to all vocalisations. For these two word-stage categories, the proportion of approximants was greater than the proportion of fricatives whereas when all vocalisations were taken into account, the reverse was true i.e. the proportion of fricatives was greater than the proportion of approximants.

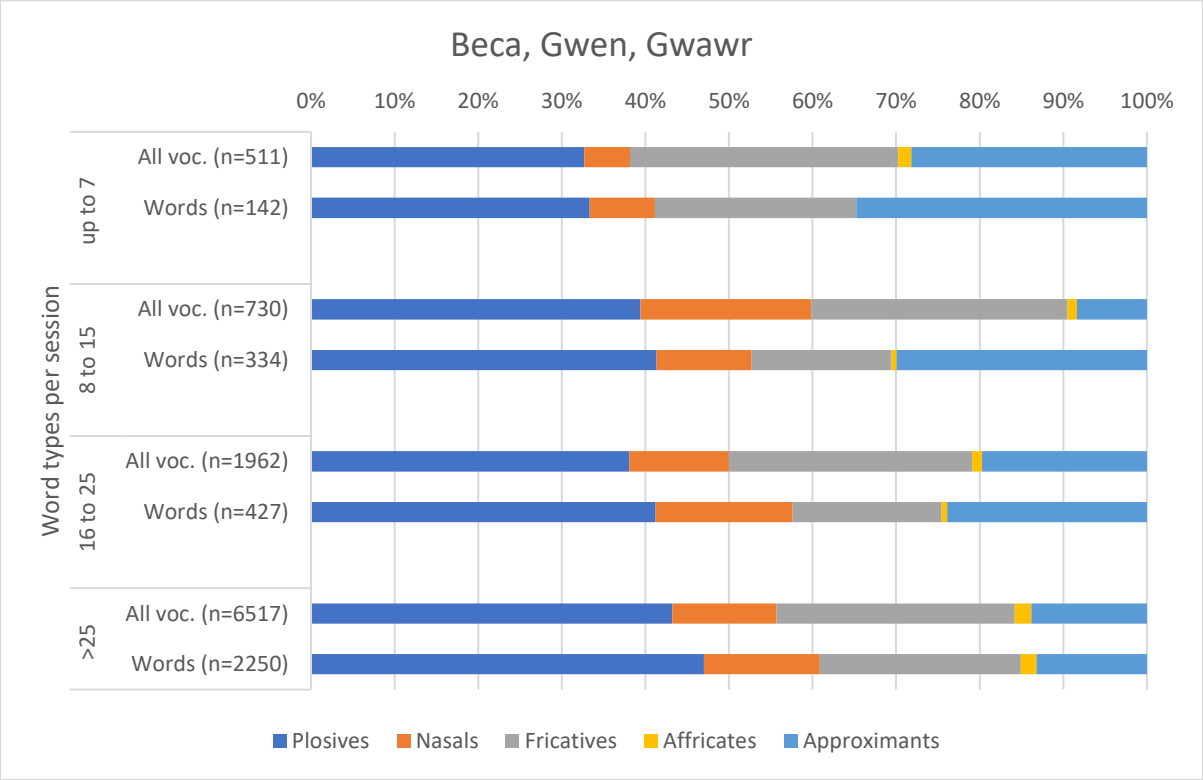


Figure 4.2 Percentage frequency of occurrence of consonants categorised according to manner of articulation, Welsh environments. Occurrence within words depicted separately from all vocalisations. Total number of consonants produced depicted as n-value.

The results for the English environment are depicted in Figure 4.3 with a comparison being made between occurrence within all vocalisations and words only at each word-stage. Inspection of Figure 4.3 revealed that, in the same way as for the Welsh environment, there was little change in the relative proportions of each manner category within the consonants produced by the children over time. The differences seen above between the values noted for all vocalisations and those for words only were not seen within the data amassed from sessions where the language of the environment was English.

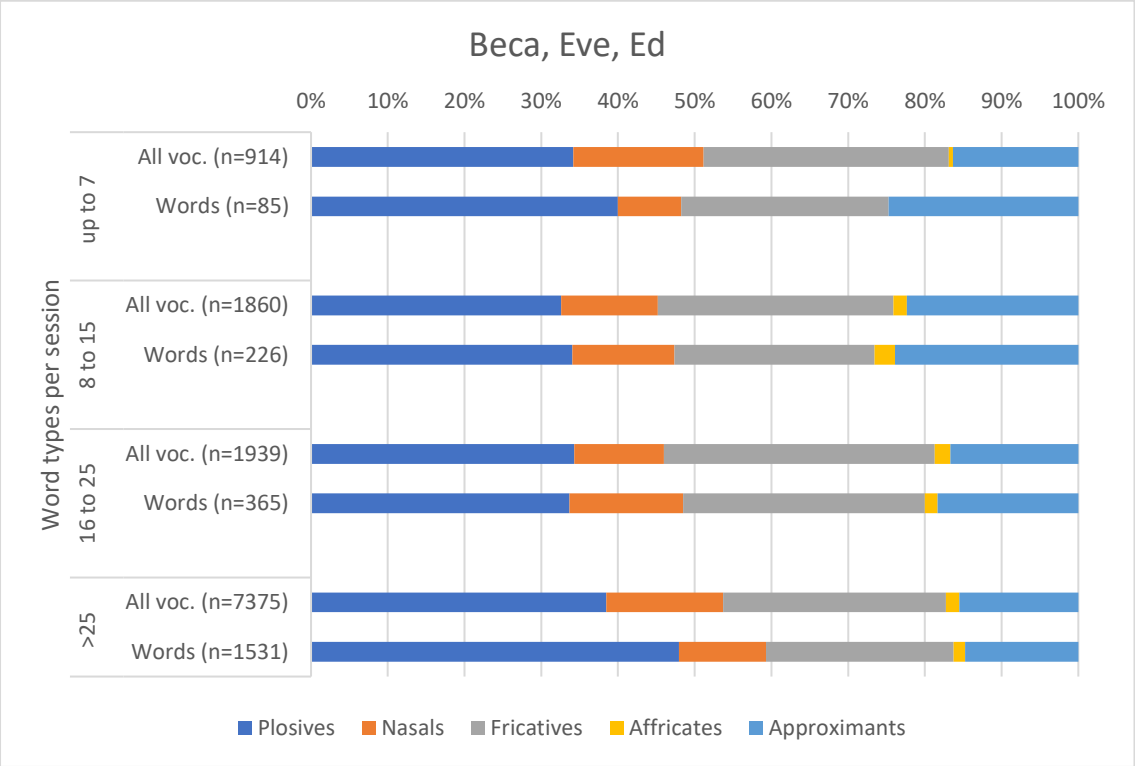


Figure 4.3 Percentage frequency of occurrence of consonants categorised according to manner of articulation – English environment. Occurrence within words depicted separately from all vocalisations. Total number of consonants produced depicted as n-value.

In order to investigate the role of individual patterns of consonant production within these general trends, the overall percentage occurrence values for each manner of articulation were calculated individually for each child (see appendix B2 for a full depiction of these data). The general trends of consonant production for each child were in line with the group values depicted above. However, for approximants, it seemed that Beca was producing more consonants from within this category than the other participants (see Table 4.3). This is true across both the language environments with the overall proportion in the Welsh environment being 26% (n=660) as compared to 10% for both Gwen (n=232) and Gwawr (n=156) and

25% (n=691) in the English environment as compared to 10% (n=218) and 16% (n=390) for Eve and Ed, respectively.

	Welsh environment						English environment					
	Beca		Gwen		Gwawr		Beca		Eve		Ed	
	n	%	n	%	n	%	n	%	n	%	n	%
All vocalisations	660	26	232	10	156	10	691	25	218	10	390	16
Words	232	26	57	10	47	10	166	27	36	7	66	16

Table 4.3 Each child's production of approximants in all vocalisations and words, Welsh and English environments

4.3.2 Manner of articulation: Within-child comparison

With the aim of exploring percentage occurrence of manner categories within different language environments within a single child, a cross-linguistic comparison of Beca's consonant production was undertaken (see Figure 4.4). Overall totals were compiled from all the included sessions featuring Beca (see Table 4.2 for details of which sessions were included). Inspection of Figure 4.4 revealed a high degree of similarity in the proportions of consonants produced that were assigned to the various manner categories. This cross-linguistic similarity was apparent when all vocalisations were considered as well as for the words only subset.

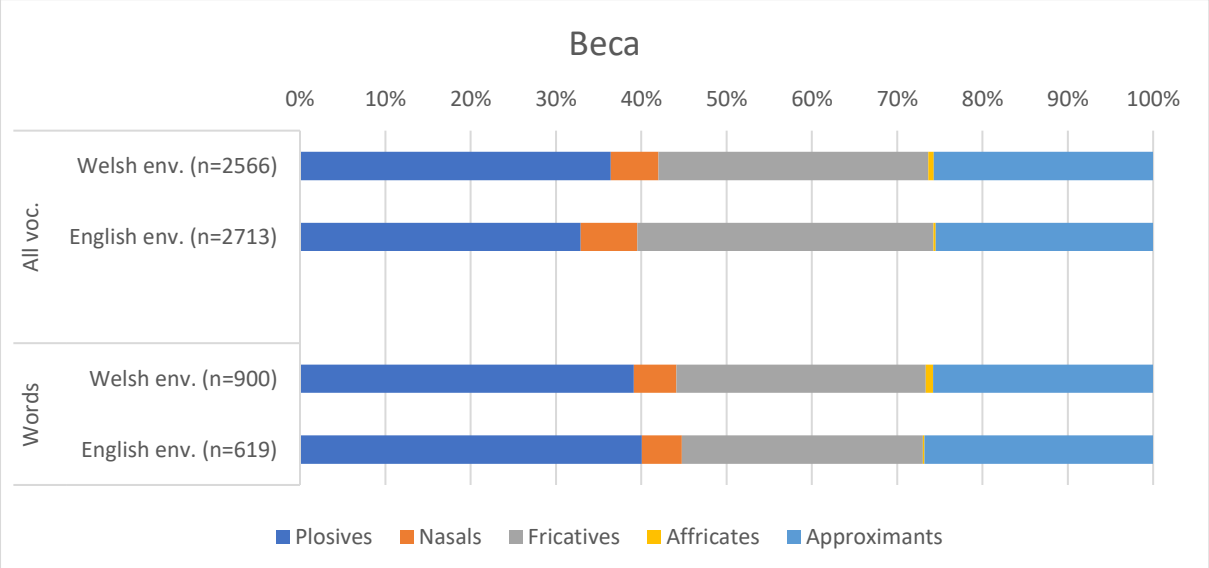


Figure 4.4 Overall percentage frequency of occurrence of consonants categorised according to manner of articulation – comparison of Beca's production across Welsh and English environments. Occurrence within words depicted separately from all vocalisations. Total number of consonants produced depicted as n-value.

Further investigation of the role of the ambient language in the nature of consonant production was undertaken through comparison of individual sessions. Sessions were matched in terms of age and word-stage so that the key difference between them was the language of the environment. This led to two specific time points being included in this analysis, denoting Beca's consonant production patterns at the start and end of the single-word period (see Figure 4.5). Inspection of Figure 4.5 revealed that during the earlier stages of linguistic development, there was a greater degree of difference seen between the percentage frequency of occurrence of the various manner classes within the consonants produced by Beca across the Welsh and English environments. When all vocalisations were considered, there was a greater preponderance of fricatives and fewer approximants produced in the English environment as compared to the Welsh environment. Looking at the vocalisations categorised as words, the preference for approximants was even more apparent within the Welsh environment. Also, the proportion of plosives and fricatives was less within her words produced in the Welsh environment, as compared to the English environment. By the end of the single-word period, these differences were no longer apparent, and a high level of similarity was observed at the '25+' word-stage.

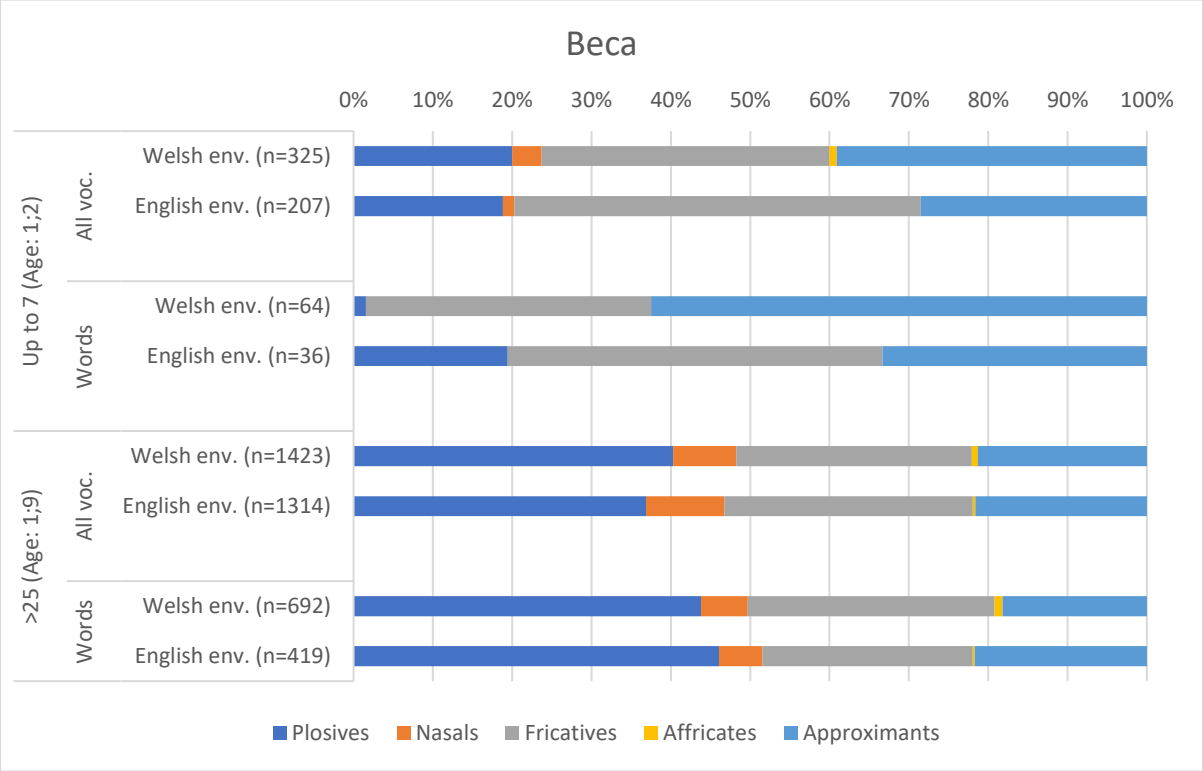


Figure 4.5 Percentage frequency of occurrence of consonants categorised according to manner of articulation – Beca only. Occurrence within words depicted separately from all vocalisations. Total number of consonants produced depicted as n-value.

4.3.3 Place of articulation: Between-child group comparison

In accordance with Chin (2003), consonants were categorised based on five broad places of articulation: *labial*, which included bilabial and labiodental; *coronal*, which included interdental, dental, alveolar and post alveolar; *palatal*, which included retroflex and palatal; *velar*; and *postvelar*, which included uvular, pharyngeal and glottal. The relative frequencies of occurrence for consonants being produced at these places of articulation are depicted in Figure 4.6 below with the values for all vocalisations being depicted separately from the vocalisations that were identified as words. Inspection of this figure led to two main observations. Firstly, consonants belonging to all place of articulation categories were produced, but they occurred at varying frequencies. The most common place category was postvelar and the least common was velar. Labial and coronal place categories were produced at similar frequencies but were less common than postvelar and palatal consonants, but more common than velar. Secondly, when investigating the role of the ambient language within these overall frequencies, it was seen that there was a great deal of similarity across Welsh and English environments in terms of the frequencies of the various place of articulation categories.

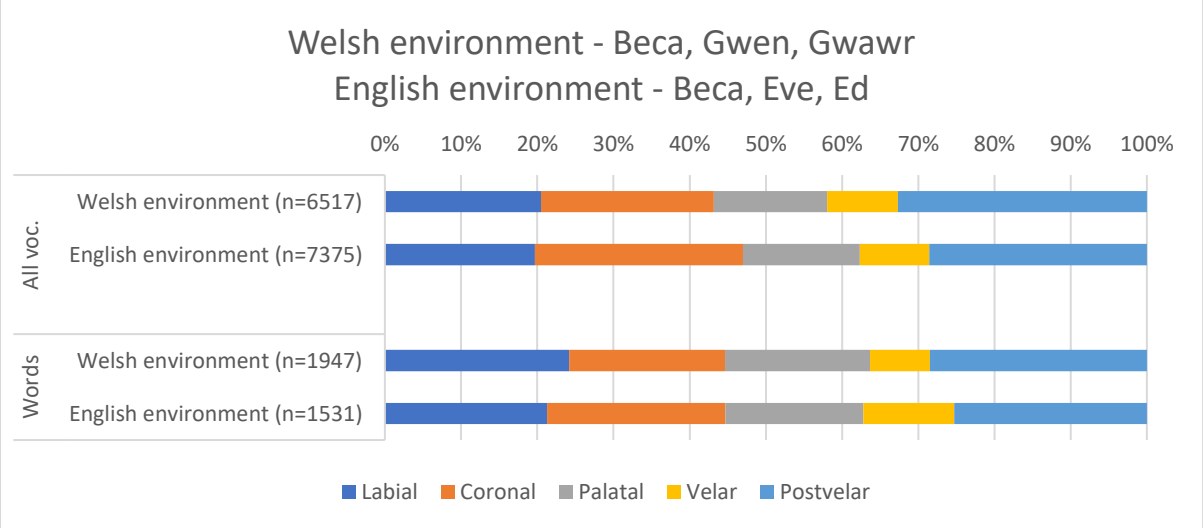


Figure 4.6 Percentage occurrence of consonants according to place category; comparison of Welsh and English environments for all vocalisations and words only. Total number of consonants produced depicted as n-value.

In the same way as for manner of articulation, above, the data were then further separated according to word-stage category in order to investigate whether patterns of occurrence changed over time. The results for the Welsh-environment group are depicted in Figure 4.7 with percentage frequency of occurrence across all vocalisations being depicted first,

followed by the frequency values for the subset of vocalisations identified as words. Inspection of this figure revealed variation in the relative frequencies of place categories occurring at different time points. Drawing attention initially to the values amassed for all vocalisations, the postvelar place category remains common across all time points with

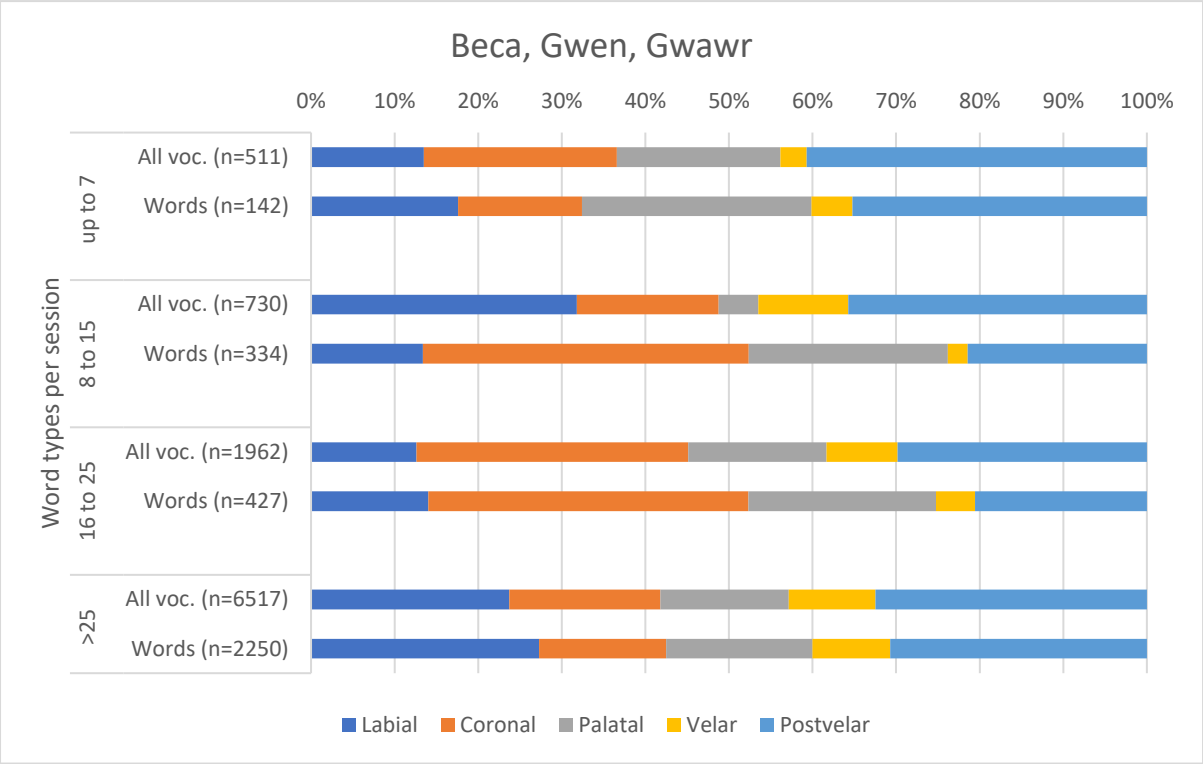


Figure 4.7 Percentage frequency of occurrence of consonants categorised according to place of articulation – Welsh environment. Occurrence within words depicted separately from all vocalisations. Total number of consonants produced depicted as n-value.

percentage frequencies of 41% (n=208), 36% (n=263), 30% (n=586) and 33% (n=2118) being shown across the developmental trajectory. There is considerable variation seen for the other four place categories with coronal consonants being the next most common at the first and third word stage depicted (i.e. 'up to 7' and '16 to 24') whilst this is true for labial consonants for the other two word stage categories ('8 and 15' and '>25'). When percentage frequencies were depicted separately for the various word stage categories, the patterns of occurrence of place of articulation categories within the words only subset were different to those observed when all vocalisations were taken into account. At the '8 to 15' word stage, a higher occurrence of coronal and palatal consonants was shown within the words subset as compared to all vocalisations. This was matched with labial, velar and postvelar consonants being produced at far lower frequencies. At the '16 to 25' word stage, there was a similar

pattern except that the labial consonants were produced at similar frequencies regardless of vocalisation type.

The results for the English environment are depicted in Figure 4.8 below. Inspection of this figure revealed greater stability in the frequency values for the different place of articulation categories over time, although there were some fluctuations, as well. Specifically, coronal consonants were the most common across all vocalisations for the earlier word stage categories whilst consonants produced at the postvelar place of articulation were more prevalent at the later stages. When comparing relative frequencies according to vocalisation type, there were observable differences at the 'up to 7', '8 to 15' and '16 to 25' word-stage categories whilst the '>25' category displayed a greater degree of similarity in frequency of occurrence within all vocalisations as compared to the vocalisations identified as words. At 'up to 7', the words only subset showed a greater proportion of palatal consonants and fewer labial consonants as compared to the values amassed for all vocalisations. At '8 to 15', there was a greater proportion of coronal consonants produced in all vocalisations as compared to words only, alongside slightly higher values for palatal, velar and postvelar in words as compared to all vocalisations. At '16 to 25', there is a greater occurrence of coronal consonants and fewer postvelars in words than all vocalisations.

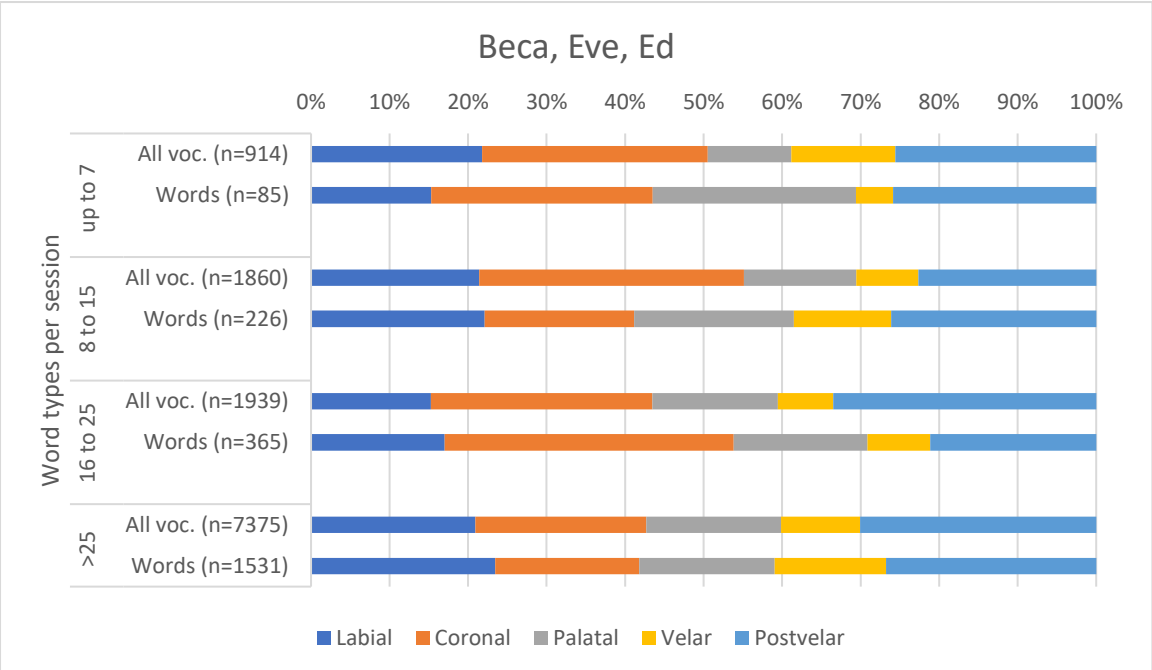


Figure 4.8 Percentage frequency of occurrence of consonants categorised according to place of articulation – English environment. Occurrence within words depicted separately from all vocalisations. Total number of consonants produced depicted as n-value.

Once again, individual patterns of consonant production were investigated to ascertain the role of individual difference within these general trends (see appendix B3 to see these data depicted in full for each child). There is greater variation seen in the overall percentage frequencies shown for each child when consonants are categorised according to place of articulation rather than manner of articulation (discussed in 4.3.1 above). Postvelar and coronal categories had the greatest degree of variation across participants and are therefore depicted here. The occurrence of postvelar consonants across the five participants is shown in Table 4.4. Inspection of the values depicted for all vocalisations revealed variation across the children in both language environments with a range from 36% (n=928; Beca) to 28% (n=670; Gwen) seen in the Welsh environment and from 38% (n=1019; Beca) to 16% (n=366; Eve) in the English environment. Comparing these values to those shown for the subset of vocalisations classified as words revealed even greater variation. In the Welsh environment, the range was 37% (n=332; Beca) to 19% (n=110; Gwen) and in the English environment, the range was 38% (n=236; Beca) to 11% (n=55; Eve).

	Welsh environment						English environment					
	Beca		Gwen		Gwawr		Beca		Eve		Ed	
	n	%	n	%	n	%	n	%	n	%	n	%
All vocalisations	928	36	670	28	537	34	1019	38	366	16	718	30
Words	332	37	110	19	114	25	236	38	55	11	95	23

Table 4.4 Each child's production of postvelar consonants in all vocalisations and in words, Welsh and English environments

Variation across participants was also shown for coronal consonants, particularly within the English environment (see Table 4.5). A particularly high occurrence was seen for Eve, where 44% (n=980) and 40% (n=197) of consonants produced were coronal, in all vocalisations and words respectively. In the Welsh environment, values were similar across the three children when all vocalisations were taken into account, and for the words only subset Beca had a comparatively low occurrence at 13%, as compared to 27% seen for Gwen and Gwawr.

	Welsh environment						English environment					
	Beca		Gwen		Gwawr		Beca		Eve		Ed	
	n	%	n	%	n	%	n	%	n	%	n	%
All vocalisations	560	22	548	23	375	24	453	17	980	44	581	24
Words	118	13	158	27	123	27	68	11	197	40	92	22

Table 4.5 Each child's production of coronal consonants in all vocalisations and in words, Welsh and English environments

4.3.4 Place of articulation: Within-child comparison

In the same way as for manner or articulation, a cross-linguistic comparison was undertaken for Beca specifically, in order to further explore the role of the ambient language within the place of articulation frequency data. The overall totals compiled for all included sessions featuring Beca are shown in Figure 4.9. Inspection of this figure revealed a high degree of similarity in the proportions of place categories shown across the Welsh and English language environments, particularly when all vocalisations were considered. Within the

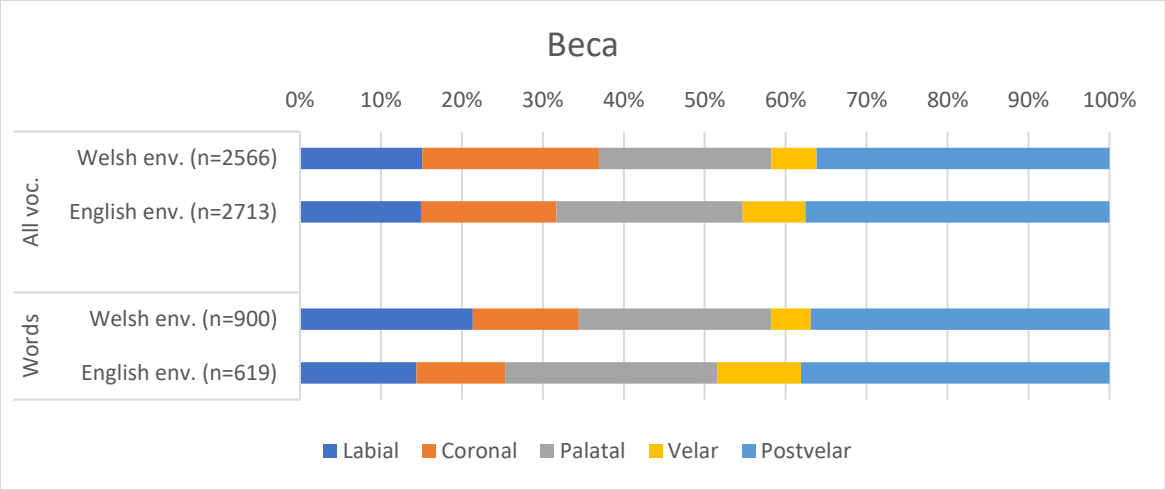


Figure 4.9 Overall percentage frequency of occurrence of consonants categorised according to place of articulation – comparison of Beca's production across Welsh and English environments. Occurrence within words depicted separately from all vocalisations. Total number of consonants produced depicted as n-value.

words only subset, there was a small amount of variation with the labial and velar categories. Consonants produced in the Welsh environment showed a greater proportion of labial consonants as compared to the English environment, with values of 21% (n=189) and 14% (n=89) respectively. The reverse was true for velar consonants, with a value of 10% (n=62) for the English environment and 5% (n=45) for the Welsh environment.

Once again, individual sessions were compared where it was possible to match sessions captured in each language environment in terms of word-stage as well as age. In Figure 4.10 below, the frequency of occurrence of the various place categories is depicted for the early sessions captured, where Beca produced up to 7 word types and for the final sessions where the number of word types exceeded 25. Inspection of this figure revealed various cross-linguistic differences, with the earlier sessions demonstrating these to a greater degree. At age 1;2, where Beca was producing up to 7 word types within the 30-minute session, there is variation seen for the proportion of both the labial and palatal consonants. For the labial consonants, this is particularly prominent when all vocalisations are considered with frequency values of 10% (n=33) and 25% (n=52) being shown for the Welsh and English environments respectively. For the palatals, a similar degree of cross-linguistic difference was seen across all vocalisations and words, with a range from 45% (n=29; Welsh environment) to 31% (n=11; English environment) being shown in the words only subset. As demonstrated by sessions where more than 25 different word types were recorded, by the end of the single-word period, these cross linguistic differences were less apparent. Where all vocalisations were considered, there was a slightly higher proportion of labials produced in the Welsh environment whilst a slightly higher proportion of velars was seen in the English environment. For the words only subset, these trends were also seen along with a higher proportion of coronals in the Welsh environment and a higher proportion of velars in the English environment. Interestingly, there is an overall reduction in the proportion of postvelar consonants produced by Beca in both languages across the two time points, with 47% (n=152; Welsh environment) and 44% (n=91; English environment) consonants produced in all vocalisations categorised as such at 1;2, whilst only 34% (n=477) and 36% (n=469) belonged to this category at 1;9.

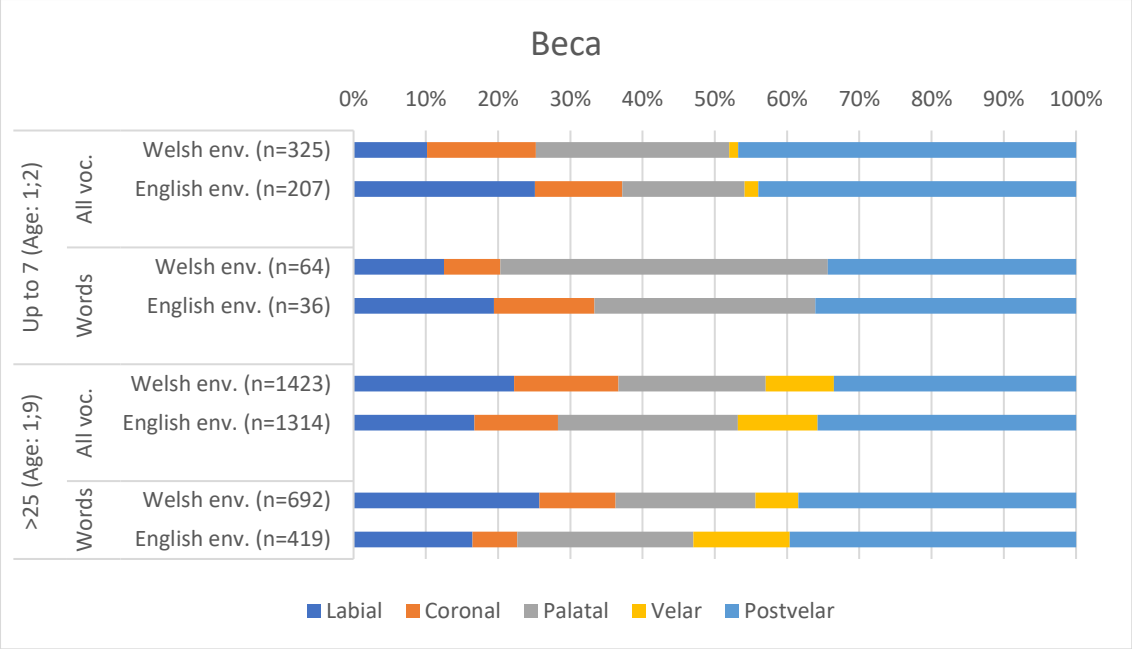


Figure 4.10 Percentage frequency of occurrence of consonants categorised according to place of articulation – Beca only. Occurrence within words depicted separately from all vocalisations. Total number of consonants produced depicted as n-value.

4.4 Preferred sounds

Finally, children's preference for individual consonants was explored. For each 30-minute analysed session, the percentage frequency of occurrence of each consonant within all consonant tokens produced by the child was calculated. When discussing the degree of sound preference seen by individual children of this age, there are two criterion levels that have been suggested in the literature (Amayreh and Dyson, 2000). Where a single consonant makes up more than 10% of the overall sample, it is labelled a *preferred sound*. It is rare for a single consonant to be produced at a frequency of over 20% but when it does occur, is seen as particularly strong indicator for preference. For the purposes of this study, such sounds were labelled *highly preferred sounds*. For each session, consonants are listed within three frequency of occurrence categories in Tables 4.6 and 4.7: 5-10%, >10-20% and >20%. Within each of these, consonants are listed in order of most common to least common. Inspection of this table revealed a number of interesting patterns. All children produced [h] at a frequency high enough for it to be deemed a preferred sound in some, if not all, of their sessions. Interestingly, Gwawr was the only participant not to have it as a preferred sound in her first recorded session. A strong preference for the glottal stop [ʔ] was seen within four of the participants' productions, with Beca, Gwen, Gwawr and Ed producing it more than 10%

of the time for the majority of their sessions. Eve was the exception as [ʔ] did not appear once in the '>10-20%' nor '>20%' categories.

Age	No of consonant tokens	Percentage occurrence		
		5-10%	>10-20% Preferred sound	>20% Highly preferred sound
Beca				
1;2;1	325	l ʎ	j ʔ	h
1;3;20	818	l s	ʔ j h d	
1;5;19	468		h j	ʔ
1;9;9	1423	b g	ʔ h j	
Gwen				
1;1;6	487		m ʔ	h
1;2;27	708	j m ʔ g	d h	
1;4;7	1196	b d ʔ m g	h	
Gwawr				
1;1;7	186	h ɸ p j	d	ʔ
1;3;1	243	m h β	d b ʔ	
1;4;13	436	j g	m d h	ʔ
1;6;1	695	j	h m	ʔ

Table 4.6 Percentage occurrence of most frequently produced sounds in all vocalisations; Welsh environment

Aside from the [h] and [ʔ], the other patterns of preference identified were less pervasive with fewer participants being affected. Beca demonstrated a preference for the approximant [j] which she produced at a frequency of >10-20% during all sessions in both language environments. Ed was the only other child to produce [j] at this frequency and he did so only in one session, at 1;3;29. The other 4 children, apart from Beca, seemed to favour a nasal, either [m] or [n] instead, although this was seen at varying degrees. For example, Eve produced her preferred nasal [n] at a frequency of at least 10% in the 5 sessions that were recorded between 1;1;21 and 1;8;0 whilst Gwen's preference for [m] was only seen within the first of her sessions, recorded at 1;1;6.

The final pattern of note is the use of the plosive [d] across children. This sound appeared as a preferred sound in at least one session across all children recorded in the Welsh environment. In the English environment, Eve showed preference for [d] across all of her sessions but this was not the case for Beca or Ed where it did not appear at all at a frequency of over 10%.

Age	No of consonant tokens	Percentage occurrence		
		5-10%	>10-20% Preferred sound	>20% Highly preferred sound
Beca				
1;2;4	207	β ʔ b	j	h
1;3;25	463	ʎ d	ʔ h j l	
1;5;19	729		ʔ h j	
1;9;9	1314	g m	ʔ h j	
Eve				
1;1;21	368	m j g	d h n	
1;3;1	490	h b m		d
1;4;28	729	g	h d n	
1;7;3	588	ʔ ʃ j b	d n h	
1;8;21	349	k n	b h d	
1;9;21	561	d ʔ b k t m h		
Ed				
1;2;17	339	d m ŋ g n j	h ʔ	
1;3;29	668	m d w ʔ b	j h	
1;5;17	344	j n	h ʔ	m
1;8;0	622	m j	h	ʔ
1;9;11	787	n d j	ʔ m h	

Table 4.7 Percentage occurrence of most frequently produced sounds in all vocalisations; English environment

The findings reported above relate to all vocalisations produced by each child within the 30-minute analysed session, regardless of communicative function. In line with the aims of the study, a further analysis was undertaken to identify preferred sounds within the subset of vocalisations deemed to be words. Identifying those consonants produced at high frequencies

in words would enable further conclusions to be drawn regarding the motoric and gestural abilities displayed by children within their early vocalisations and how this relates to the abilities displayed as early words are produced. To this end, the preferred sounds in words were also identified, with Table 4.8 relating to the sessions captured in the Welsh environment and Table 4.9 relating to the sessions captured in the English environment.

Beca		
1;2;1 (n=65)	j	42%
	h	32%
1;3;20 (n=314)	j	23%
	d	17%
	ʔ	16%
	h	10%
1;5;19 (n=82)	ʔ	26%
	j	18%
1;9;9 (n=690)	ʔ	22%
	h	15%
	b	11%
	j	11%

Gwen		
1;1;6 (n=41)	m	27%
	ʔ	12%
	g	10%
1;2;27 (n=41)	d	32%
	j	14%
1;4;7 (n=391)	b	11%
	g	10%

Gwawr		
1;1;7 (n=37)	d	38%
	ʔ	35%
	j	16%
1;3;1 (n=31)	m	23%
	d	19%
	b	13%
	ʔ	10%
1;4;13 (n=124)	m	22%
	d	20%
1;6;1 (n=264)	m	18%
	ʔ	16%
	h	10%

Table 4.8 Percentage occurrence of preferred sounds in words; Welsh environment

Inspection of Table 4.8 revealed that for every sessions analysed, there was at least one consonant that made up more than 10% of the sample of consonants produced and could therefore be described as a preferred sound. For nine of the eleven sessions depicted, this could also be extended to the higher criterion of 20% occurrence, and in three of these, there were two consonants produced at frequencies higher than 20%. Interestingly, the two sessions that did not feature a consonant with at least 20% occurrence were the final sessions analysed for those children, 1;4;7 for Gwen and 1;6;1 for Gwawr. Preferences identified within production of words are similar to those seen above where all vocalisations were taken into account. The preference for [ʔ] holds true for words despite the fact that the glottal stop does not have phonemic status in either Welsh or English (see section 3.2 for a depiction of the sounds system of Welsh). Beca, in particular, produces this sound at high frequencies with 26% (n=21) being recorded at 1;5;19 and 22% (n=152) at 1;9;9. In the Welsh environment, [j] also features heavily in Beca's productions in words with a very high frequency of 42% (n=27) recorded at 1;2;1 and over 10% occurrence recorded for her three

other sessions. For Gwen, an interesting finding is that [ɡ] is a preferred sound in words when this did not feature at a frequency higher than 10% in all vocalisations.

Inspection of Table 4.9 revealed a preference for [ʔ] once again for Beca from 1;3;25 onwards, and for Ed in his later sessions 1;8;0 and 1;9;11. Beca's samples revealed a preference for [j], which mirrored trends seen for consonant production in the Welsh environment. Interestingly, [β] and [ɡ] were produced at a frequency of over 10% in the English environment whilst not featuring as preferred sounds in the Welsh environment indicating a cross-linguistic difference. For Eve and Ed, there were sounds that were recorded at frequencies of over 10% in words whilst this was not the case in all vocalisations. Sounds particularly favoured in words for Eve were [j] at 1;2;21 which had an occurrence of

Beca		
1;2;4 (n=37)	h	35%
	j	22%
	β	11%
1;3;25 (n=49)	j	27%
	ʔ	22%
	h	16%
1;5;19 (n=116)	ʔ	22%
	j	18%
1;9;9 (n=422)	ʔ	26%
	j	16%
	h	12%
	g	12%

Eve		
1;1;21 (n=20)	d	30%
	j	20%
	t	10%
	h	10%
1;3;1 (n=29)	d	41%
1;4;28 (n=96)	h	23%
	g	15%
	k	10%
1;7;3 (n=135)	d	19%
	ʃ	16%
	n	15%
1;8;21 (n=167)	b	23%
	k	14%
	d	11%
	h	11%
1;9;21 (n=247)	b	12%
	k	11%
	d	10%

Ed		
1;2;17 (n=29)	d	24%
	j	17%
	b	10%
1;3;29 (n=81)	m	23%
	j	15%
	w	14%
1;5;17 (n=106)	m	34%
	n	17%
1;8;0 (n=115)	m	21%
	ʔ	19%
1;9;11 (n=189)	m	19%
	ʔ	16%
	n	10%

Table 4.9 Percentage occurrence of preferred words in words; English environment

20% and a preference for [k] that was seen in three of her other sessions, 1;4;28, 1;8;21 and 1;9;21. At 1;3;1 she only had one preferred sound, [d], but this was recorded at a particularly high frequency of 41% (n=12). Ed demonstrated preference for [m] which echoed the high occurrence of this sound in all vocalisations but on the other hand, his early preference for [j] was not seen when all vocalisations were taken into account.

Preference for producing particular sounds has been investigated whilst considering sounds with high occurrence across all vocalisations as well as those being produced frequently in words. This has allowed for investigation into the utilisation of preferred sounds as the children embark on their early word production. It can be seen that there are some sounds that maintain their high frequency status when a smaller subset of vocalisations is considered whilst the preference for other sounds only appears when analysis is limited to words.

4.5 Rate of consonant development

Detailed inspection of the vocalisations produced by these 5 children at various time intervals allowed for comparison of individual trajectories in terms of rate of consonant development. The rate of consonant development was evaluated by examining the number and nature of the consonants produced by the children within their vocalisations, either taken as a whole or for a specific subset. This, in turn, illustrated their progression towards mastery of the articulatory gestures needed to produce the words and phrases of their language or languages.

Recall from 3.6.3 that all consonants produced at least twice were included in the inventory for that session. The compilation of inventory lists based on all vocalisations allowed for evaluation of all the consonants that were being produced, irrespective of the status of the vocalisation in which they appeared, these are presented in 4.5.1 below. Then in 4.5.2, there will be a focus on a the subset of vocalisations identified as words. Here, further insights will be gained in relation to the consonants that were being produced when the children were attempting to convey meaning. In 4.5.3, the focus remains on words only but examination of consonant development is done on the basis of the nature of the consonants produced, rather than their number. The inventory lists were evaluated in relation to the consonants they contained, with greater complexity being signalled by the presence of sounds deemed to be more difficult to articulate (Montanari *et al.*, 2014; Dinnsen *et al.*, 1990).

4.5.1 Inventory size: All vocalisations

The five typically developing children in this study demonstrated consonant inventory growth over the data analysis period, as shown in Figure 4.12. Inspection of the first three graphs within this figure (i, ii and iii) revealed a steady increase in the consonant types recorded (i.e. the number of consonants included in the inventory) within the inventories of all three children recorded within a Welsh environment. The differences in home language input patterns did not seem to influence size of inventory or growth trajectory as Beca, with a dual-language home environment, displayed an inventory that grew from 18 to 39 across the data collection period and Gwawr and Gwen, with single-language home environments, displayed inventories containing 20 to 36 and 27 to 45 consonants, respectively. For Gwen and Gwawr, this steady rise in the number of consonant types recorded coincided with a rise in the number of vocalisations produced, session on session. For Beca, there was a greater degree of fluctuation between the numbers of vocalisations produced during the 30-minute period. It is reasonable to assume that a session where there were fewer vocalisations produced would mean less variety in terms of consonants produced and a smaller inventory. Interestingly, despite the reduction in number of vocalisations produced at 1;5;19, the steady growth in the size of Beca's inventory was maintained.

Inspection of the latter three graphs within Figure 4.12 (iv, v and vi) revealed that not all of the samples captured in an English environment depicted steady growth in terms of inventory size. Only Beca's data mirror the trend seen in the Welsh environment, while Eve and Ed exhibit fluctuating inventory sizes. Nevertheless, consonants were added to the inventories of both children as they progressed through the data collection period. Thus, Eve's inventory contained 26 consonants at 1;2;21, but 35 consonants at 1;9;21. Note also that the inventories compiled from sessions captured in an English environment were considerably larger at the beginning of data collection than those compiled from the Welsh environment data, which may, in part, explain why the former exhibited a flatter trajectory.

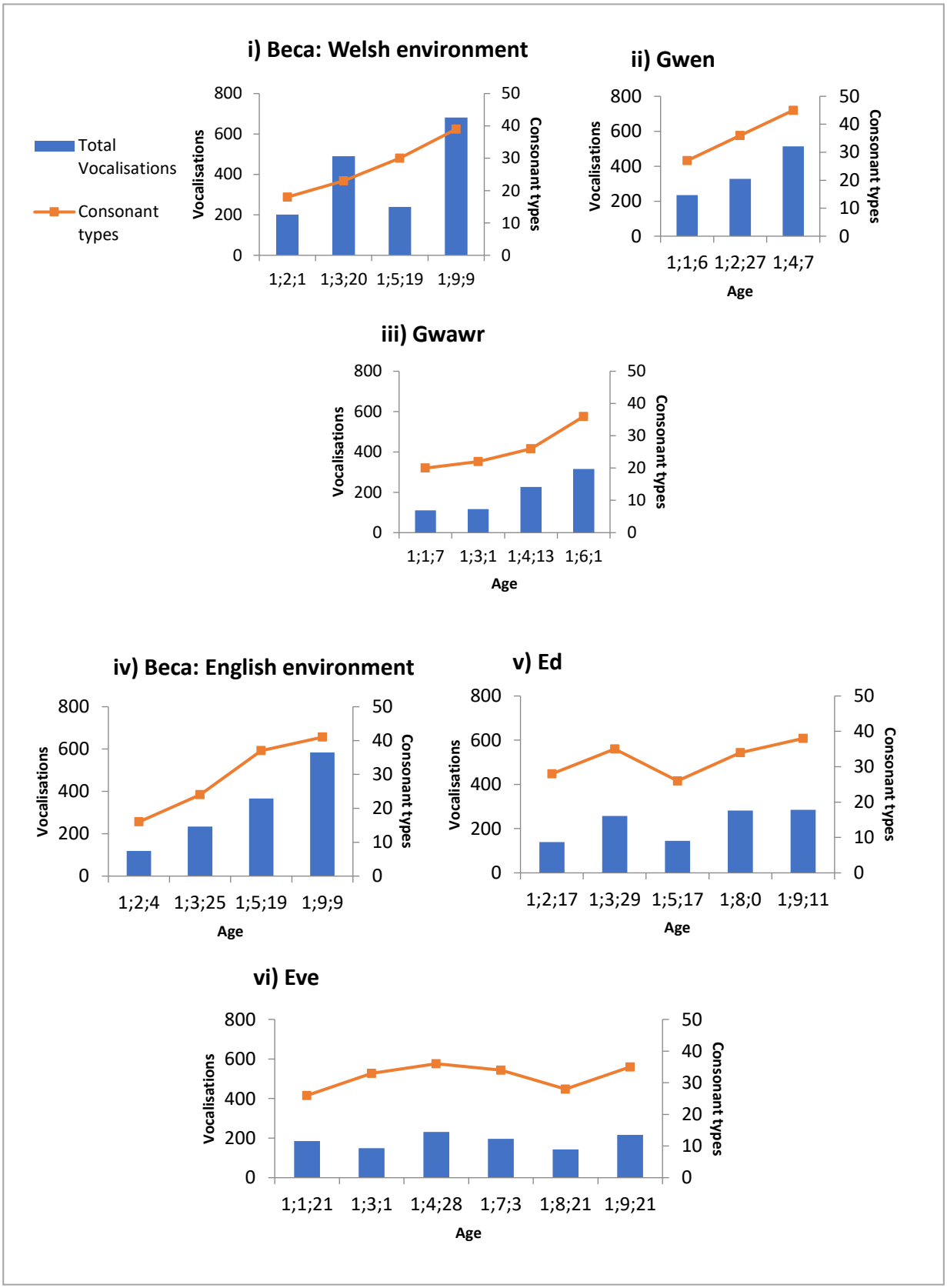


Figure 4.12 Number of consonant types as compared to the number of vocalisations produced

With reference to the data concerning number of vocalisations produced, there were sessions featuring Eve and Ed that displayed a reduction in the overall number of vocalisations produced as compared to the preceding and succeeding sessions. This was seen at 1;8;21 for Eve and 1;5;17 for Ed. In contrast to the pattern identified in Beca's data from the Welsh environment, where there is also a reduction in the overall number of vocalisations produced, these sessions do coincide with a reduction in the number of consonant types produced and therefore a smaller inventory size.

4.5.2 Inventory size: Words

With the aim of focusing on the consonant production abilities exhibited by children as they attempted to convey meaning, inventories were also compiled from the subset of vocalisations identified as words. Changes in inventory size across time are depicted for all children, separated according to the language of the environment, in Figure 4.13. Inspection of this figure revealed that there was a general increase in inventory size as time progressed and the children got older. Comparison of the trajectories seen across different children revealed individual variation in terms of the size and rate of growth at different ages. Within the Welsh environment, a reduction can be seen in the number of consonant types listed within Beca's inventory at 1;5 as compared to 1;3, as 13 and 18 consonants were recorded, respectively. This is the only time across all of the children that a decrease in the size of the inventory was seen over time. This does coincide with the reduction in total vocalisations produced by Beca at this time (as illustrated in Figure 4.12) and the reduction in the number of word tokens also (as reported in Table 4.1 above). Taking the depiction of Beca's data in Figure 4.12 and Figure 4.13 together, it appears that a reduction in the overall number of vocalisations had a greater impact on the number of consonant types produced in words than in all vocalisations.

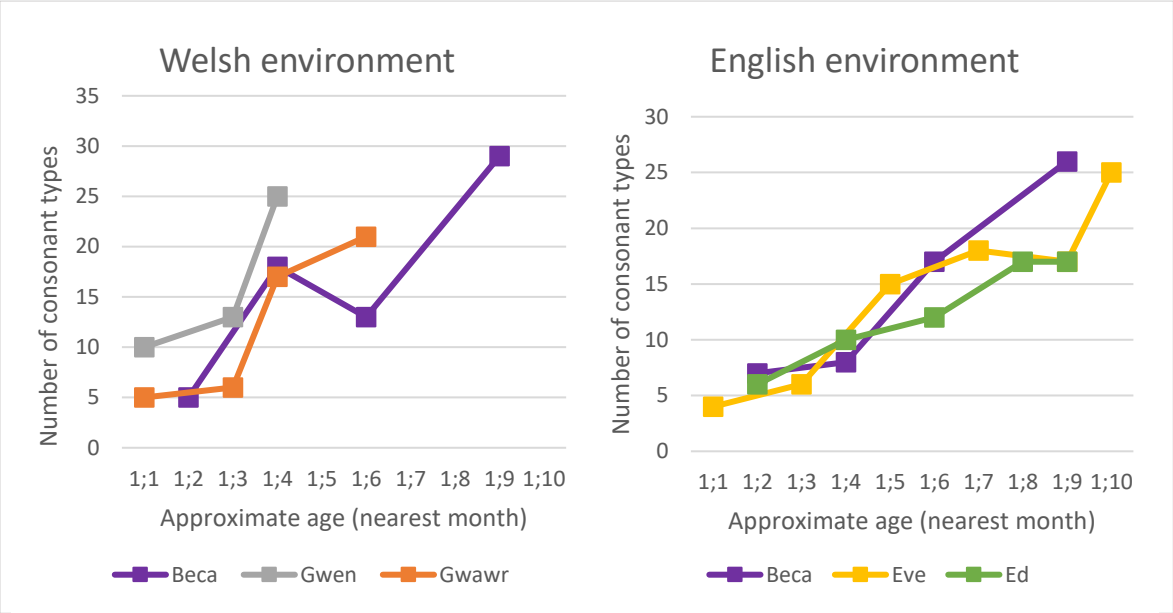


Figure 4.13 Number of consonant types produced in words over time. Welsh and English environments

4.5.3 Inventory complexity

The five typically developing children in this study demonstrated increasingly complex consonant inventories as they progressed through the single-word period, illustrated by growth in the number of different manner classes they contained (see Table 4.10 for the inventories compiled based on sessions captured in a Welsh environment and Table 4.11 for the inventories compiled based on sessions captured in an English environment). Examination of these tables revealed that session on session, there was an increase in the number of manner classes present and this was true for all five participants. At the start of data collection, when the inventories contained between 5 and 10 consonants, there was a range seen also in the number of manner categories present. The least complex inventory belonged to Beca in the Welsh environment as it only contained two different manner categories. The largest number of manner categories seen within these earliest inventories was four, with both Gwen and Ed exhibiting this level of variety and therefore the most complex inventories at that time. The earliest inventories for all children contained a preponderance of plosives, with the exception of the one compiled from Beca's Welsh environment data. Beca was seen to show an early preference for approximants with 4 and 5 different consonant types belonging to this manner category being present at 1;2;1 and 1;3;20, respectively. Approximants were also present in the early inventories of the other

children, although not in such numbers. Fricatives and nasals also featured with different combinations seen across the different participants. By the final analysed session, when the inventories contained between 17 and 29 consonants, all inventories compiled contained at least 5 different manner categories and could therefore be deemed to be commensurate in terms of complexity. By this time, affricates had been added to all inventories except the one compiled from Beca's English environment data. The uvular trill was also present in some cases. This level of complexity was reached regardless of the language of the environment.

Age	Word types	Consonants produced in words					
		Plosives	Nasals	Fricatives	Affricates	Approximants	Trills
Beca							
1;2;1	5			h		l j ʎ w	
1;3;20	22	b t d g ʔ	m n	β θ ð s ɬ h		ʊ l j ʎ w	
1;5;19	18	p b d k ʔ	m	ɸ s ç x h		l j	
1;9;9	46	b t d ɟ k g ɢ ʔ	m n ɲ ŋ	ɸ β θ ð ɬ ç ʝ ʃ x χ h	bβ	l j ʎ w	ʁ
Gwen							
1;1;6	10	p d g q ʔ	m	x χ h		j	
1;2;27	27	t d g ʔ	m n ɲ	ɸ s ç h		j w	
1;4;7	57	p b t d c ɟ k g ɢ ʔ	m n ɲ ŋ	ɸ ɣ s ç x χ h	ʧ kx	j w	
Gwawr							
1;1;7	3	d ɟ ʔ		h		j	
1;3;1	13	b d ʔ	m			ʊ w	
1;4;13	21	t d c ɟ g ʔ	m n ɲ ŋ	ɸ β s ç h		j	ʁ
1;6;1	30	p b t d ɟ k g q ɢ ʔ	m n ɲ	s ʃ h	ʧ	ʊ l j w	

Table 4.10 Consonant inventories for vocalisations identified as words; Welsh environment

A comparison of Beca's complexity trajectory across the two language environments in which she was recorded revealed overall similarity. Her earliest session in the Welsh environment did yield a slightly simpler inventory, with only fricatives and approximants being present whilst there were three categories seen in the session recorded in the English environment two days later, with the addition of plosives. By the end of the analysed period, when she was 1;9;9, Beca's Welsh environment inventory contained 6 categories and was therefore higher in complexity than her English environment inventory which contained 5 categories of consonants.

Age	Word types	Consonants produced in words Plosives	Nasals	Fricatives	Affricates	Approximants	Trills
Beca							
1;2;4	5	b d ɟ		β h		l j	
1;3;25	15	ʔ	m n ŋ	h		l j ʎ	
1;5;19	16	d ɟ ʔ	m n ɲ	ɸ θ ð s ɬ ɮ ç x ɣ h		l j ʎ w	
1;9;9	31	p b d ɟ k g ʔ	m n ɲ	ɸ β ð v ɬ ɮ ç ʝ x h		ʊ l j ʎ w	ʁ
Eve							
1;1;21	7	t d		h		j	
1;3;1	6	b d		s z h		j	
1;4;28	8	p b t d c k g ʔ	n ŋ	s z ç h	cç		
1;7;3	16	b t d c ɟ k g ʔ	n ɲ	ð z ʃ ʒ ç h		l j	
1;8;21	19	p b t d c k	m n ɲ	z ʃ ʒ h	ʧ	l j ʎ	
1;9;21	60	p b t d c k g ʔ	m n ɲ ŋ	f v s ʃ ç x χ h	ʧ	ʊ l j w	
Ed							
1;2;17	3	b d ɢ	n	h		j	
1;3;29	12	b d ʔ	m	θ h		ʊ ɹ j w	
1;5;17	13	b g ʔ	m n ɲ ŋ	x χ h		j l	
1;8;0	19	b g ʔ	m n ŋ	ɸ β s ʃ ç x h	ʧ	ʊ j w	
1;9;11	33	p b t d g ʔ	m n ŋ	ɸ β s ç h	ʤð	j w	

Table 4.11 Consonant inventories for vocalisations identified as words; English environment

4.6 Discussion

This study investigated the early phonetic and phonological development of five children deemed to be following a typical developmental trajectory. At the time of data collection, they were living in a Welsh-English bilingual community and experiencing different patterns of language use within their homes. At regular intervals between the ages of 1;1 and 1;11, as the children progressed through the single-word period, detailed investigation of their consonant production took place and cross-linguistic comparisons were made as the recordings had taken place in both Welsh and English language environments.

The results revealed that consonants were produced at varying frequencies depending on their manner and place of articulation suggesting that various biological and linguistic factors were at play. A great deal of similarity was seen across the two language environments, but differences were identified in particular areas. Specifically, the between-child group values compiled for the place of articulation categories showed a higher proportion of plosives being produced in all vocalisations produced in the Welsh environment as compared to the English environment. Also, where the focus was on place of articulation, there was greater fluctuation seen in the proportional frequencies of place categories over time in the Welsh environment, as compared to the group values compiled for the English environment. Where within-child comparisons were made in relation to the frequency of occurrence of place and manner categories, cross-linguistic differences were seen at the early stages of development but were no longer present when the sessions captured towards the end of the single-word period were compared. Many individual differences were also identified suggesting that the children approached the challenge of developing the necessary skills to convey meaning in the ambient language(s) in different ways. Further insights were gained into the vocal behaviours of individual children through identification of those consonants produced at particularly high frequencies within the samples. These preferred sounds were present in all of the analysed samples demonstrating regular use of a small number of vocal motor schemes (see section 2.3 for further discussion) within the production of words and non-words. Where analysis focused on the rate of consonant development, the five children reported in this chapter demonstrated improvements in their phonetic ability across the time period. This was demonstrated by an increase in the size and complexity of their consonant inventories.

In what follows, the findings drawn from these results will be discussed. This will focus initially on the role of the ambient language as cross-linguistic similarities and differences are discussed, with reference to between- and within-child comparisons (section 4.6.1). Then, consonant production over time will be discussed with consideration of the developmental trajectory and associated biological and linguistic factors (section 4.6.2). Finally, there will be consideration of how the findings reported in the chapter relate to the development of the necessary knowledge and skills for successful word production. Detailed examination of the children's consonant production behaviours allows for a number of insights to be gained, but this only goes so far in exploring their journey towards meaningful verbal communication. The phonetic abilities examined here provide a basis for construction of their phonological

system. The relationship between their overall consonant production abilities and those behaviours that show themselves in words has key theoretical implications. These will be discussed here in light of the insights that can be gained through investigation of consonant production with a view to further assertions being possible during the next Chapter where the focus is on the production of word forms in typical development.

4.6.1 The role of the ambient language

As the role of the ambient language was considered in relation to the production of consonants in early development, the overarching finding was that there were many similarities seen across the Welsh and English environments. These similarities were related to both the nature and rate of phonological development. Cross-linguistic comparison of consonant production in children has led researchers to provide evidence for ambient language influence (section 2.3.3). The similarity observed in the consonant production behaviour across the Welsh and English environments means that evidence of ambient language influence is limited. In considering why might this be the case, it is worth noting that there is a great deal of overlap between the sound systems of Welsh and Welsh English (Mayr *et al.*, 2017; Mennen *et al.*, 2020; Penhallurick, 2004). Where studies have drawn conclusions regarding the impact of ambient language characteristics on consonant production, it has been possible to draw on particular differences within the sounds systems of the languages involved. This is not possible for Welsh and English as all of the consonants expected to be used within early speech development are shared. There are some sounds found in Welsh that do not occur in English, such as [ɬ] and [r̥ʰ], but they do not appear until a later stage of development (Munro *et al.*, 2005).

However, in the context of overall similarity, there were also some differences worth noting. Firstly, there was a difference in the overall frequency of plosives produced across the two language environments, with a greater number being produced in the Welsh environment. There are many examples in the literature where differences in the frequency of specific consonant types have been related to language-specific characteristics within the language of the environment (e.g. Amayreh and Dyson, 2000). It may be that plosives are more commonly produced in Welsh but no data on this are available currently. Although corpus data for Welsh do exist (e.g. Ellis *et al.*, 2001), they have been orthographically recorded and

analysed; therefore it is not possible to ascertain frequency data for specific sounds or sound classes.

The second difference has to do with the within-child comparisons made regarding the proportion of manner and place categories. When all analysed sessions were taken together, Beca's consonant production was similar across the manner and place categories for sessions captured in the Welsh and English environments. However, when the comparison focused on sessions featuring fewer than 7 word types, cross-linguistic differences became apparent in the occurrence of both manner and place categories. This could be related to the fact that at an earlier stage of development, fewer utterances are produced, leading to the specific items that made up Beca's early lexicon in each language having a greater influence. Cross-linguistic differences were also seen in the preferred sounds that were identified within Beca's word production. Amayreh and Dyson (2000) investigated the use of preferred sounds in children being exposed to Arabic but their study did not contain bilingual participants. The difference in the sounds that were produced at particularly high frequencies could be related to lexical items selected by Beca in each language e.g. in her final recorded sessions at 1;9 she attempted 'gone' 26 times in the English environment and 'bib' (*beep beep)* 23 times in the Welsh environment.

4.6.2 Consonant production over time

When considering this period of development and the nature of consonant development within it, it is worth keeping in mind that this is a period characterised by variability and change (Vihman, 2014). Despite these expected fluctuations, trends do exist in terms of consonant production and changes that are likely to occur over time. Plosives and nasals produced at the front or back of the mouth are considered to be sounds that occur in early vocalisations produced by children across a range of languages (Stoel-Gammon, 1985; Robb and Bleile, 1994; Vihman, 2010). The findings reported in this chapter were in line with what has been found previously, with plosives being the most prevalent manner of articulation across both language environments, and labial and post-velar being the most prevalent place of articulation. These commonalities seen in the productions of young children, regardless of the language they are hearing, provides support for the influence of biological factors in governing the relative frequency of sounds in early vocalisations (MacNeilage, Davis and Matyear, 1997; Vihman, 2014).

Where changes over time are concerned, there are two aspects reported within this chapter that contribute directly to this discussion. Firstly, the overall trends in the occurrence of manner and place categories did not change substantially over time. Previous studies have asserted that there is an order of emergence when it comes to the sounds produced by children in early speech development (section 2.3.3). In this study, when consonants were categorised according to manner or place of articulation, the relative distribution of the categories did not change over time. It is likely that the static nature of these distribution patterns was due to the relatively short timeframe in which the data collection took place. All sessions analysed occurred within the single-word period and therefore related to the same period of development.

However, outside of the frequency of occurrence of manner and place categories, there was evidence that consonant production changed over time. There was an increase in the number of consonants seen within the inventories compiled for all five children reported in this chapter. Furthermore, the complexity of the inventories compiled increased. Whether rate of consonant development is being considered in terms of inventory size or complexity, the findings presented here are in line with those of previous studies (Fabiano-Smith and Barlow, 2010; Robb and Bleile, 1994; Stoel-Gammon, 1987; Dinnsen *et al.*, 1990). Furthermore, differences were seen in the way that preferred sounds were being utilised, with earlier sessions featuring a greater number or highly preferred sounds, i.e. those with a prevalence that exceeded 20% of the total consonants produced. This could be due to younger children showing greater reliance on familiar articulatory movements, or *vocal motor schemes* (Vihman and Croft, 2007).

There were some cross-linguistic differences seen as consonant production over time was examined, with the Welsh environment demonstrating more variation than the English environment. This was apparent when the proportion of manner categories produced in all vocalisations was compared to words. For the earliest and latest word-stage categories, proportions were the same in all vocalisations and words but this did not hold true for the word-stage categories in between (‘8 to 15’ and ‘16 to 24’). The Welsh environment data also demonstrated greater variation across the word-stage categories in relation to the percentage occurrence of place of articulation categories. Such variation over time was not seen in the English environment. One reason for this could have been that the children that

belonged to the Welsh group, particularly those from a single-language home, were younger than those who belonged to the English group. It could be therefore that the differences seen bear a greater relation to the ages of the participants and the timeframes of data collection than language-specific factors.

4.6.3 Individual patterns

Individual differences were identified at various points during the presentation of the results within this chapter. This supported the notion that exists in the literature that all children follow individual paths in their journey towards target-like speech (section 2.3.4). Vihman, Ferguson and Elbert (1986) found that some aspects of children's speech were more susceptible to individual variation. From a segmental perspective, this included velars, nasals, fricatives and liquids.

Beca showed a preference for approximants across both language environments. This was apparent as frequencies were calculated for the different manner categories and within the preferred and highly preferred sounds identified within all vocalisations and words. Beca also had a preponderance of post-velar consonants within her vocalisations, although this did decrease over time. In a similar way, Eve showed a preference for coronal consonants. Speech production at this time in development is characterised by the utilisation of familiar motoric routines that have a role to play in pre-speech as well as early word production.

The purpose of this chapter was to examine consonant production as a pre-cursor to the investigation of the syllable and word shapes produced by the same participants. Phonetic development begins during the pre-speech stage and continues throughout early and middle childhood (MacNeilage, Davis and Matyear, 1997). Through repeated use of the consonants that make up the language or languages heard in their environment, children begin to abstract the necessary patterns for construction of their phonological system or systems. The next chapter will contain the empirical data collected in relation to word production, with the focus remaining on typical development.

5 Production of early words in typical development

5.1 Introduction

This chapter aims to investigate early word production, and through this seeks to observe and understand the patterns that occur when a child begins to produce vocalisations with intent. Word production is the observable behaviour that reflects the construction and development of the phonological system. Investigation of early word production behaviour over time allows for conclusions to be drawn regarding biological and linguistic factors, contributing to our understanding of the nature and trajectory of phonological development. This study provides an opportunity to examine word production within two separate language environments and make comparisons both across children and within the same child.

The chapter begins by reporting on the word production behaviour of the participants of this study as spontaneous speech samples were collected at regular intervals within the single-word period. The target words attempted by the children within the sessions analysed are investigated in terms of their structural properties, with overall trends in terms of word shape production being reported for target words of increasing length. The three sections that follow focus on specific structural properties, syllable number, onset patterns and coda patterns, investigating the correspondence between the children's productions and the target words they were attempting. In order to make comparisons, all target words and word production attempts were coded according to word shape. With the aim of identifying cross-linguistic differences that were apparent across the Welsh and English environments, group data were compared to look for overall differences between the word shapes produced by the three children captured in each language environment. Additional data synthesis to compare Beca's word production behaviours across each of her language environments allowed for within-child cross-linguistic comparison. The aim was to ascertain whether she was exhibiting the same early word production behaviours in each of her languages, thus indicating the existence of degrees of separation and interaction.

Coding and categorisation according to word shape allowed for systematic investigation of the target words and word production attempts that were present in the data collected. Following on from this, there was a focus on the interactions between the word shapes and the segmental constraints (Vihman, 2010). The selected and adapted forms from individual

samples were identified and presented in word shape categories, before templates featuring specific segments or segmental patterns were described.

Finally, variability in word production within the same session became the focus of investigation. Over each 30-minute period under scrutiny, there were many instances where the same word was attempted multiple times. Comparison of these attempts revealed a great deal of variation in their segmental and structural make-up. Calculations made to examine differences in variability across children are reported in section 5.6. Changes in variability over time are also examined, as degrees of variability across word productions are likely to change over time, as linguistic development takes place.

5.2 A closer look at the words produced

5.2.1 Types and tokens produced over time

All vocalisations uttered by each participant within a given time period were analysed within this study, regardless of their communicative status. To address the aims of the study, there was a need to categorise the vocalisations produced and identify which ones belonged to the words sub-set (see 3.6.2 for a full explanation of the word identification procedure employed). Within this procedure, the definition of a word was fairly broad, with vocalisations deemed to signal environmental sounds and exclamations, e.g. 'miaw' and 'uh-oh', being included. The number of word types and tokens identified within each session is presented in Table 5.1 below.

Inspection of Table 5.1 revealed that the number of words produced increased as the children got older and this was true of both types and tokens. As discussed previously in 4.2 each child followed a different trajectory in terms of the number of words produced, which meant that there was variation in the time it took for them to produce at least 25 words within the 30-minute session (see section 4.2.1 for a full discussion of word-stage and an explanation of the word-stage categories assigned).

Age (nearest month)	Beca				Gwen		Gwawr		Eve		Ed	
	Dual language home				Single language home							
	Welsh environment		English environment		Welsh environment				English environment			
	Types	Tokens	Types	Tokens	Types	Tokens	Types	Tokens	Types	Tokens	Types	Tokens
1;1					10	18	3	20				
1;2	5	35		20					7	9		
1;3					24	94	13	20	6	13	3	22
1;4	21	77		28	57	176	21	66			12	36
1;5									8	44		
1;6	18	47		56			28	114			13	43
1;7									16	62		
1;8											22	50
1;9	59	318		204					18	68		
1;10									57	108	28	74

Table 5.1 Number of word types and tokens produced by each child in each session, Welsh and English environments

Following application of the word identification procedure (Vihman and McCune, 1994), further categorisation took place where words were labelled as Type A or Type B according to whether a conventionalised gloss could be assigned (see section 3.6.2 for a detailed explanation of this additional categorisation procedure). The analyses presented in sections 5.3 through 5.5 include Type A words only, as a conventionalised gloss was needed in order to compare the child's vocalisations to the adult target in terms of syllable structure and contents. A total of 1564 type A words were produced by the five typically developing children across a total of 26 analysed sessions. In section 5.6, where the variability data are reported, both Type A and Type B words have been included in this analysis.

5.2.2 Word shape inventory for target words

It was necessary to get a sense of the types of words that the children were attempting to produce during the single-word stage. To this end, the word types attempted during all sessions were coded on the basis of their word shape and the prevalence of each shape was calculated across all sessions captured in each language environment. The inventory of word shapes is depicted in Figure 5.1, and includes both the number of types and the percentage occurrence for each word shape. Percentages were calculated using the total number of word

types recorded for each language. Where there was repetition of the same word across sessions featuring the same child, only one occurrence was included. Where multiple children attempted the same word, all occurrencces were counted according to type. Inspection of the figure revealed similar occurrence of word shapes across the language environments with the lexicons of all children featuring a preponderance of CV, CVC and CV|CV words. Interestingly in the Welsh environment, the number of CV|CV words exceeded the number of monosyllabic targets whereas in the English environment there were substantially fewer CV|CV words than CVC or CV words. This suggests a greater likelihood for the selection of disyllabic targets when exposed to Welsh within the environment than when exposed to English.

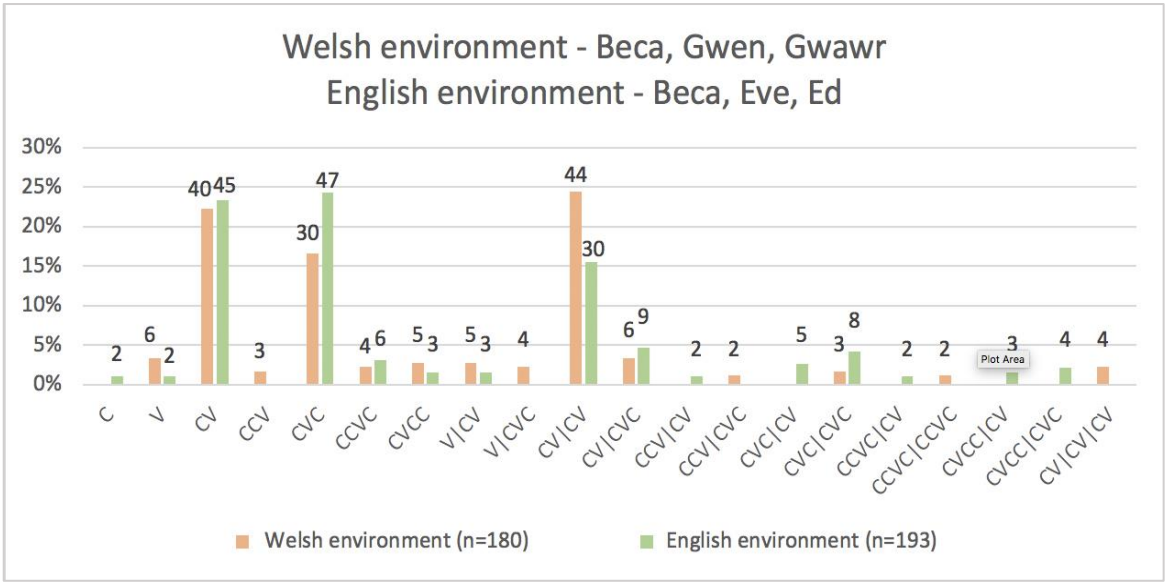


Figure 5.1 Word shape inventory, target word types: Welsh and English environments

Grouping of occurrence data across participants allowed for cross-linguistic comparisons to be made. It is acknowledged that individual difference could be a factor here as target words are selected by each of the five participants. In order to explore whether the individual target word occurrence trends were broadly similar to those identified within the group data, further inventories were compiled depicting the relative frequencies of each word shape within the target words attempted by each child (see Appendix C1). Inspection of these figures revealed that the word shapes seen to be highly prevalent in the group data, CV, CVC and CV|CV, were the three most prevalent shapes for all five participants regardless of ambient language.

5.2.3 Popular word shapes across each language environment

The investigation of target word characteristics was extended by means of a more detailed analysis of the word shapes produced when attempting the production of words of

Figure 5.2 Most frequently occurring shapes for word production attempts according to target word syllable number and the language of the environment

mono-, di- and multi-syllabic targets across all children within each participant group is depicted in Figure 5.2.

Examination of this figure revealed a fair amount of similarity across language environments. For monosyllabic targets, the most frequently produced word shapes were the same across both language environments. However, they were produced at different proportions with a fairly equal occurrence of CV and CVC word production attempts in the English environment, yet the occurrence of CV words in the Welsh environment was more than double the occurrence of CVC words. For disyllabic targets, the three most frequently occurring word shapes were CV|CV, CV|CVC and CV|CV|CV across both language

environments. This is in line with the cross-linguistic differences identified in the syllable shape inventories above (see section 5.2.2).

5.3 Syllable number

The target words attempted were categorised in terms of the number of syllables they contained, resulting in three groups: monosyllabic target, disyllabic target and multisyllabic target. The children's word production attempts contained syllables of varying number. The number of syllables found in the child's word production attempt did not always match the number of syllables within the target words, revealing patterns of syllable addition and omission.

5.3.1 Degree of match to target according to word-stage

Before examining the nature of the differences between the child's production and the target word in more detail, an examination of how often these differences occurred across the various recorded sessions was undertaken. To this end, the children's ability to adhere to the structural properties of the target words they were attempting was examined. In this case, the number of syllables contained in the target word was compared to that seen within the child's production and a percentage degree of match to target was calculated. In order to investigate how this changed as the children progressed through the single-word period, sessions were grouped together in the same way as had been done within Chapter 4. Progression through the single-word period, i.e. linguistic advancement, was indicated by the production of a greater number of word types within subsequent recorded sessions. Grouping sessions where a similar number of word types had been produced allowed for the creation of word-stage categories, with the most representative sessions captured for each child being selected for inclusion within the group values (see section 4.2.1 for details of this categorisation process). As the focus here was syllable number, the numbers of words attempted that belonged to each target word category (mono-, di-, multi-syllabic) were counted and each one was compared to its target on the basis of syllable number. Values indicating the proportion of words produced containing the same number of syllables as their target words are displayed in Table 5.2. This was depicted separately for each word-stage.

WELSH ENVIRONMENT						
Word-stage category	Monosyllabic target		Disyllabic target		Multisyllabic target	
	n	Match to target	n	Match to target	n	Match to target
up to 7	12	75%	30	77%	0	
8 to 15	15	83%	9	90%	0	
16 to 24	98	78%	70	77%	1	50%
25+	147	63%	157	77%	17	55%
ENGLISH ENVIRONMENT						
Word-stage category	Monosyllabic target		Disyllabic target		Multisyllabic target	
	n	Match to target	n	Match to target	n	Match to target
up to 7	15	94%	21	100%	0	
8 to 15	40	77%	18	90%	1	100%
16 to 24	52	63%	36	77%	1	50%
25+	144	75%	97	82%	2	67%

Table 5.2 Number of attempts to produce various target types that matched the target in terms of syllable number: Word-stage category comparison

Inspection of Table 5.2 revealed that there were fluctuations in the degree of match in both language environments. For sessions captured in the English environment, the values for percentage match for the earliest word stage category were high across all target word lengths. This was followed by a decrease for the subsequent two word-stage categories and an increase for the final word-stage category. For the sessions captured in the Welsh environment, the degree of fluctuation was far greater. However, a decrease in accuracy in relation to syllable number was observed following the '8 to 15' word-stage category for mono- and disyllabic targets.

5.3.2 Word production attempts in different language environments: Between-child comparison

Cross-linguistic similarities and differences were identified across the two participant groups, i.e. those captured in a Welsh environment and those captured in an English environment. The frequency of each target word type (i.e. mono-, di- and multi- syllabic) varied with

mono- and disyllabic targets produced in far higher numbers than multisyllabic targets. Frequencies also varied across the language environments. Comparison of the *n* numbers depicted in Figure 5.3, showed similar numbers of mono- and disyllabic targets being attempted in the Welsh environment. This was in contrast to the English environment, where a far higher proportion of monosyllabic targets was attempted, as compared to disyllabic targets attempted.

For each target word category, the frequency of occurrence of mono-, di- and multi- syllabic word production attempts was compared across language environments. The relationship between the number of syllables present in the target word and the number of syllables produced by the child was examined. The data from all children captured within each language environment was grouped together for cross-linguistic comparison (see Figure 5.3). Examination of this figure revealed that for the most part the children's vocalisations matched the syllable number of the target word. For monosyllabic targets, 30% of word production attempts were di- or multisyllabic indicating a fair amount of syllable addition. For disyllabic targets, a greater proportion of adherence to the target was seen, with small numbers of attempts being mono- or multisyllabic. A particularly small number of disyllabic targets were produced as monosyllables in the English environment, suggesting that syllable omission was rare here. For multisyllabic targets, the overall number attempted in each language environment was small. Over half of the attempts made were multisyllabic, but that is not to say that they matched their target in terms of syllable number. All words with three or more syllables were included in the multisyllabic category so further specification in this regard is not possible. The remaining attempts to produce multisyllabic targets were mono- or disyllables demonstrating a high degree of syllable omission. Adaption to a monosyllable rather than a disyllable was more common in the English environment.

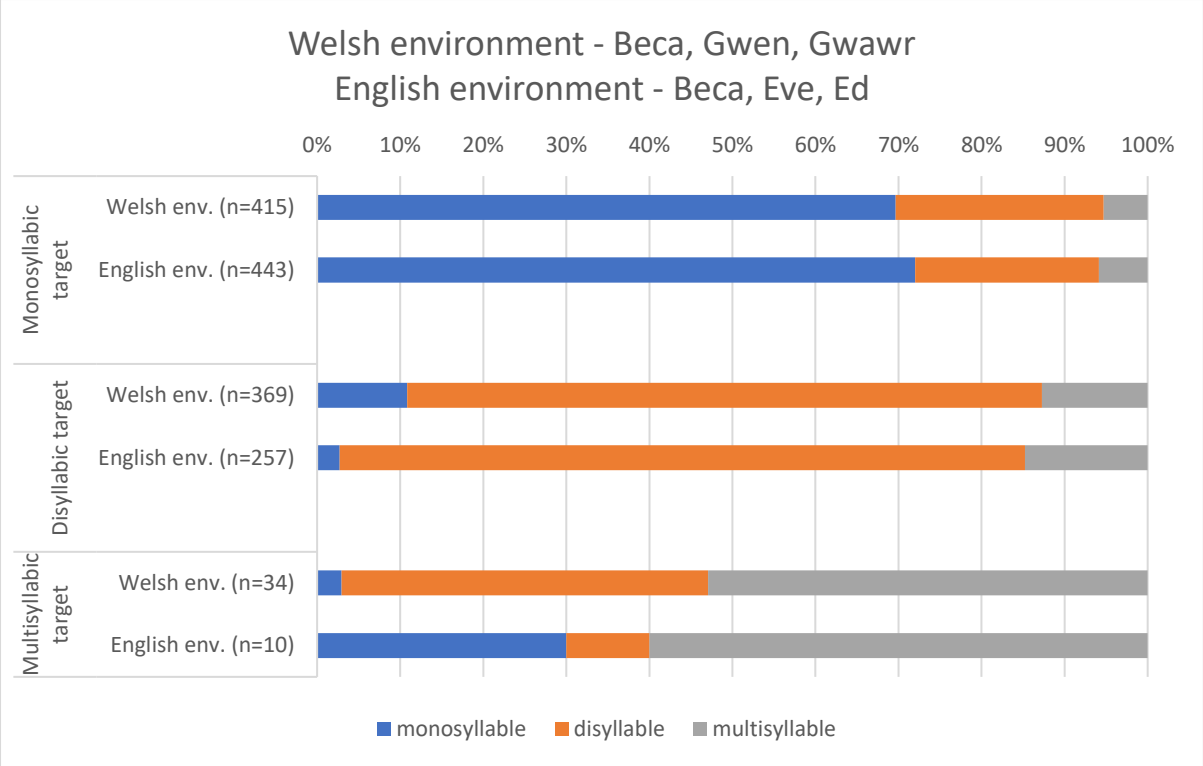


Figure 5.3 Word production attempts of differing lengths according to the number of syllables within the target word: Between-child cross-linguistic comparison

5.3.3 Word production attempts in different language environments: Within-child comparison

The proportion of mono-, di- and multi-syllabic targets that Beca produced as mono-, di- and multi-syllables was examined in order to make a within-child comparison, see Figure 5.4. Inspection of this figure revealed that Beca's adherence and deviation from the target word's syllable number contained within the word that she was attempting was similar across the language environments, particularly for mono- and di-syllabic targets. Multisyllabic targets revealed a stark difference across the language environments as a large proportion of multi-syllabic targets in the Welsh environment were produced as disyllables. However, this category contained a very small number of items compared to the other categories and therefore this difference needs to be interpreted with caution. Within the mono- and di-syllabic target categories, the only difference of note was that there were no examples of disyllabic targets being produced as monosyllables in the English environment, yet this was true for 12% of disyllabic targets in the Welsh environment. This suggests that Beca

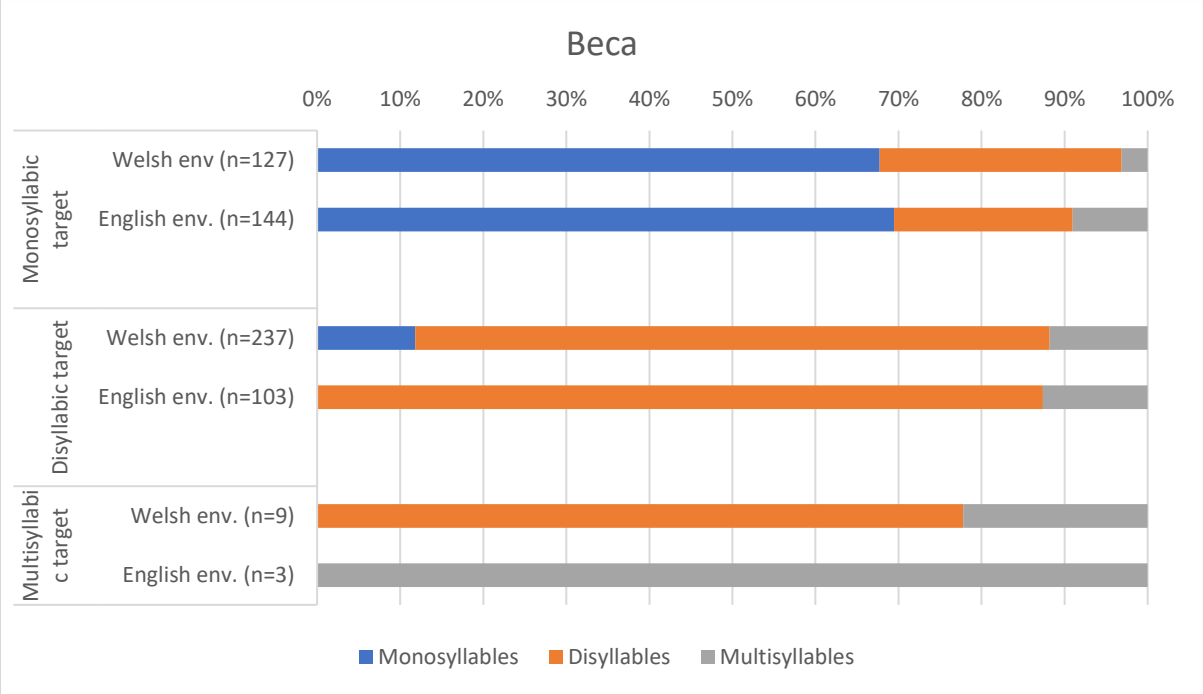


Figure 5.4 - Word production attempts of differing lengths according to the number of syllables within the target word: Within-child cross-linguistic comparison

demonstrated different patterns of syllable omission across her two language environments. In accordance with this finding, the fact that she produced 7/9 of her multisyllabic targets as disyllables could also be taken as evidence for a tendency to omit syllables in the Welsh environment. The cross-linguistic similarities and differences found through this examination of Beca's word production attempts across each of the language environments in which she resides revealed similar trends to those seen through the comparison of group values in the previous section.

5.3.4 A focus on individual samples: Identification of templates

A difference in the number of syllables contained within the target word and the number of syllables produced as it was attempted indicated the addition and omission of syllables. Depicting syllable addition and omission through percentage occurrence only goes so far in illustrating this phenomenon. A closer look at syllable addition and omission patterns was undertaken through application of the templatic approach (Vihman and Croft, 2007). Recall from 2.3.4 that this approach was devised by Vihman and colleagues as a method of accounting for the fact that children's productions at this age are often more similar to each other than they are to their intended target. The theory is based on the principle that children match their own production abilities to the auditory input they are hearing in the

environment. This allows them to produce first words that match their articulatory ability and are therefore relatively accurate. These are described as *selected forms* within the framework. The child is then said to adopt these word shapes or *templates* when attempting novel words, leading their word production attempts to be similar in segmental and structural content to their selected forms. These are known as *adapted forms*.

With the aim of exploring syllable addition and omission through application of the templatic approach, word production attempts conforming to the same word shape were grouped together and patterns were identified. This detailed analysis was undertaken for three of the participants, each representing one of the participant groups. The included word production attempts that took place in the Welsh environment were those of Gwen, who was only hearing Welsh at home and Beca, who was hearing Welsh and English at home. Those that took place in the English environment came from Eve, who was only hearing English at home and Beca, once again.

The analysis was separated according to the shape of the selected forms and the resultant adapted forms. Initially, the focus was on word production attempts with a CV word shape (see Tables 5.3 and 5.4) followed by an investigation of those with a CVCV shape (see Tables 5.3 and 5.4). Where possible, selected forms pertaining to each template were identified across sessions and participants. Adapted forms, i.e. those which did not conform to the word shape in terms of syllable number, were then categorised as displaying a syllable addition or omission pattern. The selected and adapted forms conforming to the <CV> template are displayed in Table 5.3 and Table 5.4., with the adapted forms demonstrating initial syllable omission. There were three target word shapes that were produced in this way across the two language environments: CVCV, CVCVCV and VCV.

Adaptions of target words to fit the <CV> template were relatively few in number. However, they were identified across both language environments and all participants included in this analysis. Interestingly, where a multisyllabic word was adapted, it was the final syllable that was retained in all cases. In the Welsh environment, this was seen in Gwen's (1;4;07) production of the girl's name 'Maggy'/magi/ as [gʏ͡i]. In the English environment, Eve (1;9;21) produced 'kangaroo' as [ʊu]. The adaption of a VCV target word related to the same lexical item being produced across both language environments by Beca. Her production of the Welsh word for 'yes' 'ia'/ija/ demonstrated initial syllable omission as the initial syllable

was dropped and a CV word was produced in a variety of ways e.g. [ja] and [dɛ] at 1;5;19 in the Welsh environment and [ʔa·] at the same age in the English environment.

<CV>				
		Selected forms	Adapted forms	
			Syllable omission CVCV(CV) → CV	Syllable omission VCV → CV
Gwen	1;1;06	'bw' /bu/*(boo!)* [βu] 'go' [gaʊ] 'ow' /ʔəʊ/*(oh)* [ʔəʊ]		
	1;2;27	'da' /da/*(tah)* [da](3) [d̥a̤] [da::] 'dau' /daɨ/*(two)* [da:ɪ](7) [daɪ](3) [daɨ] 'bw' /bu/*(boo!)* [βu] 'go' [gaʊ] 'ow' /ʔəʊ/*(oh)* [ʔəʊ] 'na' /na/*(no)* [na](5) [ɲa]		
	1;4;07	'na' /na/*(no)* [na:] [ɲa](2) [ŋa] 'ow' /ʔəʊ/*(oh)* [ʔəʊ](7) 'go' [gɔʊ]	'Maggy' [g͡ɣi]	
Beca	1;3;20	'yeah' [jɛ̝·](2) 'da'/da/*(tah)* [dɛ̟:]		'ia'/ija/*(yes)* [ja:::] [ʎa:::]
	1;5;19	'ahh' [ʔa:] 'ow'/ʔəʊ/*(oh)* [ʔəʊ] 'dau'/daɨ/*(two)* [dəu:] 'ci'/ki/*(dog)* [kɪ̈]		'ia'/ija/*(yes)* [ja] [j̊a] [ʔa̤] [dɛ]

Table 5.3 Word production attempts adapted to CV through syllable omission, Welsh environment

<CV>				
		Selected forms	Adapted forms	
			Syllable omission CVCV(CV) → CV	Syllable omission VCV → CV
Eve	1;8;21	'na' [ŋaː]		
	1;9;21	'moo' [muː](2)	'kangaroo' [ʊu]	
Beca	1;3;25	'moo' [mu·] 'no' [nəʊ]	'ta ta' /tata/*(bye)* [fa]	
	1;5;19	'yeah' [jɛ](2)		'ia'/ija/*(yes)* [ʔa·]

Table 5.4 Word production attempts adapted to CV through syllable omission, English environment

The selected and adapted forms that conformed to the <CVCV> template are displayed in Table 5.5 and Table 5.6. Target words were adapted to this template either through syllable addition or syllable omission. Attempts to produce CV and CVC target words demonstrated syllable addition. Attempts to produce CVCVCV words displayed syllable omission. One of the ways in which words were adapted to the <CVCV> template was production of a second syllable containing repeated elements from the first. This could be described as reduplication (Grunwell, 1987). Examples from the Welsh environment included Gwen's (1;2;27) production of 'da' /da/*(tah)* as [tatʰaː] and Beca's (1;3;20) production of 'yeah' as [lɛʎɛ]. This pattern was also seen in Beca's productions in an English environment, with 'ah' produced as [hạ̈hạ̈] at 1;5;19 and 'gone' produced as [gə-gɒ] at 1;9;9. There was one example of Eve's productions following this pattern, at 1;8;21, she produced 'poo' as [bəpə̰].

Target words with a CVC shape were also adapted to the <CVCV> template. An example from the Welsh environment was Gwen (1;4;07) producing the CVC word 'pêl' /pel/ *(ball)* as [giɣaʊ], [baːʊɸ̞ʲ] and [baːɪwɜ]. An example from the English environment was Eve's (1;8;21) production of 'shoes' as [ʃiːtə̰] and [ʃi̪s̪ə̰]. Both children are adding an additional syllable, thus avoiding the production of the coda (further coda patterns are examined in 5.5, below)

<CVCV>				
		Selected forms	Adapted forms	
			Syllable addition CV(C) → CVCV	Syllable omission CVCVCV → CVCV
Gwen	1;1;06	'Peppa' /pɛpa/ [bəʊpa̰]	'go' [gəʊwu]	
	1;2;27	'Cadow' /kadəʊ/*(name for family member)* [kadəʊ]	iei' /jɛɪ/*(yay)* [hɛ·jɪ] 'da' /da/*(tah)* [tatʰa:]	'hufen ia' /hɨvɛn ja/*(ice cream)* [haja·]
	1;4;07	'haia' /haɪja/*(hiya)* [ha̰ja̰] 'hwnna' /hʊna/*(that one)* [hʊŋa] 'Mamow' /maməʊ/ [maməu] 'ta ta' /tata/*(bye)* [t̪ɛt̪a·] 'Peppa' /pɛpa/ [bɛba](2) 'o-ow' /ʔəʔəʊ/*(uh-oh)* [ʔaʔ:ɔ]	'wps' /ʔʊps/*(oops)* [ʔɔpa̰] 'ow' /ʔəʊ/*(oh)* [ʔɔpa̰] [ʔɜwɔ] [ʔɔwʊ] 'pêl' /pel/*(ball)* [giɣaʊ] [ba:ʊɸ̞] [ba:ɪwɜ] 'na' /na/*(no)* [ɲaʔə̰] 'nain' /naɪn/*(grandma)* [naʔæɪ]	'see you soon' [sizɪʊ] 'lle mae o' /ɬɛmaɨɔ/*(where is it)* [hɛjɔ]
Beca	1;2;1	'haia' /haɪja/*(hiya)* [hajɛ](4) 'helo' /hɛlɔ/*(hello)* [hɛl̪ɛ·]		
	1;3;20	'dada' /dada/*(dadda)* [dada:] 'haia' /haɪja/*(hiya)* [hɛjə̰]	'yeah' [lɛʌɛ] 'na'/na/*(no)* [hɛ̆ja]	
	1;5;19	'o-ow'/ʔəʔəʊ/*(uh-oh)* [ʔaʔəʊ] 'helo'/hɛlɔ/*(hello)* [hɛ̠ju]		
	1;9;9	'o-ow'/ʔəʔəʊ/*(uh-oh)* [ʔuʔu:](3) 'baby' [beɪbi] 'no no' [na-nəʊ]	'tri'/tri/*(three)* [ʧɪji] 'hair' [ʔɛ̆ʔɛa] 'juice' [dɨjəʊ] 'fi'/vi/*(me)* [gəβi] 'dau'/daɨ/*(two)* [ha·ji] 'cath'/kaθ/*(cat)* [ga·ʊjɛ] 'caws'/kaʊs/*(cheese)* [ɬawɛ]	'banana' [bɛbʲa] 'there we go' [heigɜ] [ʔɛgəʊ] 'goriadau'/gɔrjadaɨ/ *(keys)* [jakʰɛ·]

Table 5.5 Word production attempts adapted to CVCV through syllable addition and omission, Welsh environment

<CVCV>				
		Selected forms	Adapted forms	
			Syllable addition CV(C) → CVCV	Syllable omission CVCVCV → CVCV
Eve	1;1;21		‘toe’ [ʔɒdəʊ]	
	1;3;1	‘dadda’ [dada](2)		
	1;7;3		‘shoes’ [ʃiʒɛ] [ʃiɟ̆ă] [ʃi:da] [ʃɛ·da] [ʃida:] [ʃi:da]	
	1;8;21	‘Bella’ [bɛlạ] ‘dada’ [dada] ‘mama’ [mama](2)	‘poo’ [bəpə̰] ‘fish’ [barʧi] ‘shoes’ [ʃi·tạ] [ʃiṣạ] ‘yeah’ [həjɛ]	‘another’ [nuḍa]
Beca	1;2;4	‘baby’ [βɛβeɪ] ‘hiya’ [hạja]		
	1;3;25	‘uh-oh’ [ʔʊʔʊ] ‘hiya’ [hɛɪja:]		
	1;5;19	‘hiya’ [haɪj̈a] ‘uh-oh’ [ʔuʔu·]	‘ah’ [hạhạ] [ʔɔ:wɔ] ‘yeah’ [hɪʎə] [hijɛ] [ʔɜjɛ] [ʔijɛ]	

	1;9;9	‘baby’	[beɪbi]	‘poo’	[buçn̥]
		‘hiya’	[həja]		[bβːboçn̥]
		‘uh-oh’	[ʔəʔəʊ]	‘gone’	[gɒ·wĭ]
					[gə-gɒ](2)
					[ɟ͡ʝ̟ɟ͡ʝ̟·ɒ]
				‘mine’	[ma·jə]
				‘oh’	[ʔəʊli·]
					[ʔəʊwɒ]
				‘yeah’	[ʔijɛ](2)
					[ʔɪjia]

Table 5.6 Word production attempts adapted to CVCV through syllable addition and omission, English environment

5.4 Onset patterns

As well as the identification of differences related to syllable number, comparisons were made between target words and the children’s productions in terms of the presence and absence of onsets. To this end, the target words attempted were categorised in relation to whether they contained an onset or not. Then, the children’s word production attempts were also coded for presence or absence of an onset so that they could be compared with their targets.

5.4.1 Degree of match to target according to word-stage

Once again, adherence to the structural properties of the target words being attempted was investigated, but this time presence of the onset was under scrutiny. In accordance with the overall aim of the study to explore the developmental trajectory throughout the single-word stage, the proportion of words produced that matched their targets with regards to presence or absence of the onset was calculated for each word stage category.

Here, the target word was compared to the child’s production on the basis of presence or absence of an onset and the percentage degree of match to target was calculated. Values indicating the proportion of words that matched the target according to its onset properties are displayed in Table 5.7 Number of attempts to produce various target types that matched the target in terms of onset production: Word-stage category comparison, Welsh and English environments. This was depicted separately for each word-stage.

WELSH ENVIRONMENT				
Word-stage category	Target with onset		Target without onset	
	n	Match to target	n	Match to target
up to 7	38	81%	1	0%
8 to 15	25	96%	0	0%
16 to 24	176	97%	7	27%
25+	399	98%	4	10%
ENGLISH ENVIRONMENT				
Word-stage category	Target with onset		Target without onset	
	n	Match to target	n	Match to target
up to 7	48	96%	0	0%
8 to 15	60	100%	3	10%
16 to 27	118	100%	0	0%
25+	296	98%	0	0%

Table 5.7 Number of attempts to produce various target types that matched the target in terms of onset production: Word-stage category comparison, Welsh and English environments

Inspection of this table revealed that the overall number of target words attempted increased as the children progressed through the single-word period. For targets with onsets, a high proportion of the children's attempts also contained onsets. This was true across the various word stage categories and both language environments. The numbers of target words without onsets that were attempted were low overall, but their occurrence was higher in the Welsh environment, as compared to the English environment.

5.4.2 Word production attempts in different language environments: Between-child comparison

In the same way as was done for syllable number, between-child comparisons were made across the Welsh and English environments. Target words were categorised according to whether they contained an onset. The frequency of each target word type (i.e. with and without an onset) varied across the language environments. Comparison of the *n* numbers depicted in Figure 5.5 showed similar numbers of targets with onsets being attempted across

the Welsh and English environments. Targets without onset, however, occurred at far lower frequencies with an even smaller number being attempted in the English environment.

For each type of target word, the proportion of attempts made with and without an onset was calculated. Figure 5.5 depicts this relationship for all of the word production attempts made, separated according to language of the environment. Examination of this figure revealed the overall preference shown for production of an onset, regardless of its occurrence within the target word attempted. However, target words without onsets did result in more attempts without onsets, especially in the Welsh environment.

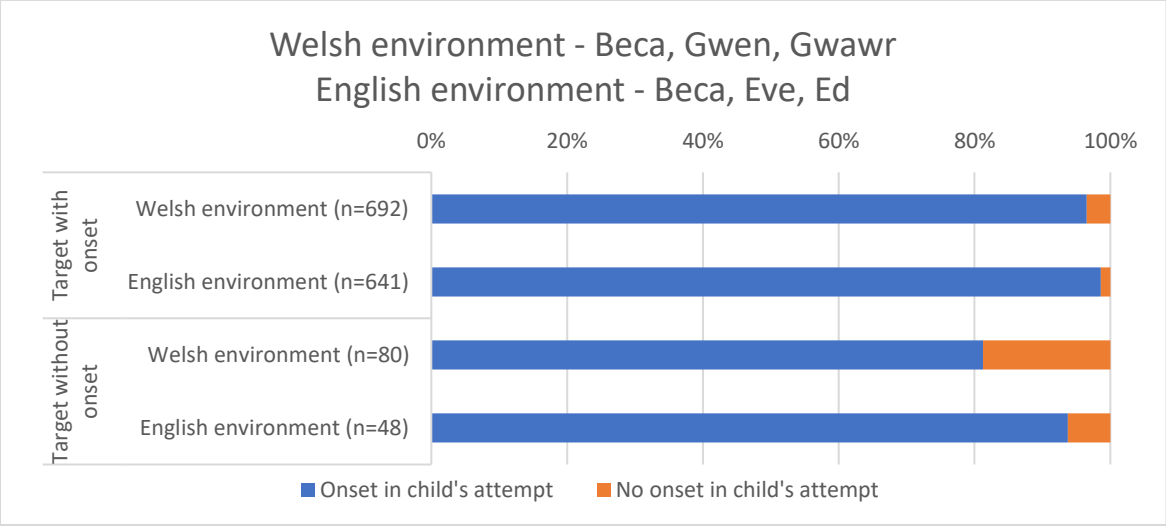


Figure 5.5 Word production attempts with and without onsets according to structure of target word: Between-child cross-linguistic comparison

5.4.3 Word production attempts in different language environments: Within-child comparison

In the same way as previously, Beca's word production attempts were examined separately with the aim of making within-child cross-linguistic comparisons. These values are depicted in Figure 5.6. Inspection of this figure revealed cross-linguistic patterns that were similar to those seen when between-child comparisons were made. Onsets were favoured in Beca's production attempts, across both target word categories. Where target words did contain an onset, there was a slightly lower proportion of attempts made in the English environment that did not contain an onset i.e. where onset omission was identified. Where targets did not contain an onset, the overall proportion of attempts containing an onset was smaller than those made for targets containing onsets. In accordance with the group values depicted

above, there were more words without onsets attempted by Beca in the Welsh environment. Interestingly, for targets without onsets, the proportion of attempts made with or without onsets was similar across both environments. This shows deviation from the group trends discussed in the previous section, where cross-linguistic differences were seen in this regard.

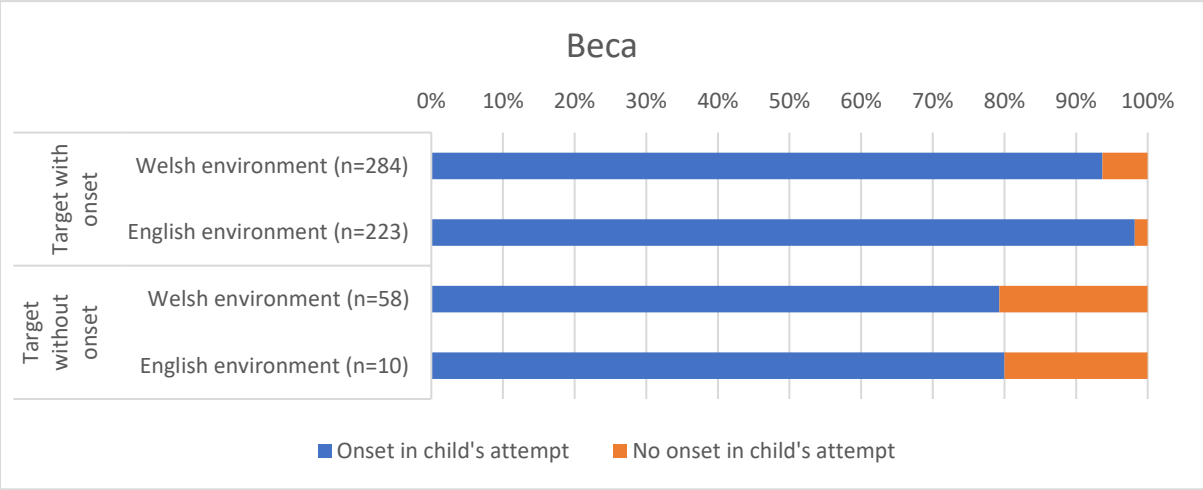


Figure 5.6 Word production attempts with and without onsets according to structure of target words. Within-child cross-linguistic comparison.

5.4.4 A focus on individual samples: Identification of templates

The presence of an onset within the target word did not always correspond to an onset being produced within the child's attempt. These differences gave rise to patterns of consonant omission and addition. Once again, individual samples collected from the participants were examined in detail and templates were identified.

With the aim of exploring onset production through application of the templatic approach, word production attempts conforming to the same word shape were grouped together and patterns were identified. In the same way as in the previous section, this detailed analysis was undertaken for three of the participants, each representing one of the participant groups. Word production attempts that demonstrated specific phenomena related to the production or absence of onsets were grouped together. Where the target did not contain an onset, many of the children's attempts contained an initial consonant. Tables 5.8 and 5.9 depict target words produced in the Welsh environment that were adapted to a template containing an onset, with Table 5.8 including those that had a CVC word shape and Table 5.9 including those with CVCV or CVCVCV word shapes.

Inspection of these tables revealed that adaption to the <CVC> template was not common in the Welsh environment, although both children analysed here did produce one adapted form each. Where the <CVCV> template was concerned, it was possible to identify more specific templates in some cases. For example, the <hVjV> template was fairly widespread in the Welsh environment. Gwen produced 'olwyn' /ɔlʊɨn/ *(wheel)* as [hajeɪ] at 1;2;27 and 'ia' /ija/ *(yes) as* [hɪjaː] at 1;1;06 and 1;4;07. This can be linked specifically to her production of 'haia' /haɪja/ *(hiya)* as [hą̈ją̈] at which was identified as a selected form in her second listed sample.

<CVC>			
		Selected forms	Adapted forms
			Consonant addition VC → CVC VCV → CVC
Gwen	1;1;06	'mam' /mam/*(mum)* [mam]	
	1;2;27	'paid' /paɪd/*(don't)* [bą̈i̯t̪]	'wff'/uf/*(oof)* [ʔuɸ] [dɪʊf]
Beca	1;9;9	'good' [gʊd]	'yli'/ʌli/*(look at this)* [ʔʌl]

Table 5.8 Word production attempts adapted to CVC through onset addition, Welsh environment

The selected form of 'haia' /haɪja/ *(hiya)* was also produced by Beca within her first and second listed sessions. Adaptation to this specific template was then seen for 'ia'/ija/ *(yes)*, which was produced as [hiˑja] at 1;2;1, [hijɛ] at 1;3;20 and [hɛɪja] at 1;5;19. Interestingly, within Beca's samples captured in the Welsh environment, adapted forms were seen to influence each other. Her production of 'yli' /ʌli/ *(look at this)* was adapted to a <CVCi> in 4 out of 5 cases which was reasonable given that the target word ends in the vowel /i/. What is notable, though, is that one of her productions of 'ia'/ija/ *(yes)* at this age was produced as [hijaːjɪ]. Adoption of the <Ci> ending is therefore seen in the attempt to produce a different word, albeit through the addition of a syllable.

<CVCV> <CVCVCV>			
		Selected forms	Adapted forms Consonant addition VCV(C) → C(C)VCV → CVCVCV
Gwen	1;1;06	'Peppa' /pɛpa/ [bəʊpa̰]	'ia'/ija/*(yes)* [hijă]
	1;2;27	'Cadow' /kadəʊ/*(name for family member)* [kadəʊ]	'a mwy'/amʊɨ/*(and more)* [ɲɛjəʊ] 'olwyn'/ɔlʊɨn/*(wheel)* [hajeɪ]
	1;4;07	'haia' /haɪja/*(hiya)* [ha̰ja̰] 'hwnna' /hʊna/*(that one)* [hʊŋa] 'Mamow' /maməʊ/*(word used to refer to her mother)* [maməu] 'ta ta' /tata/*(bye)* [t̪ɛt̪a·] 'Peppa' /pɛpa/ [bɛba](2) 'o-ow' /ʔəʔəʊ/*(uh-oh)*. [ʔaʔːɔ]	'oh no'/əʊnəʊ/ [hɲaɲaːʊ] 'ia'/ija/*(yes)* [hɪjaː](4) [ɲija]
Beca	1;2;1	'haia' /haɪja/*(hiya)*. [hajɛ](4) 'helo' /hɛlɔ/*(hello)* [hɛl̪ɛ·]	'ia'/ija/*(yes)* [hi·ja]
	1;3;20	'dada' /dada/*(dadda)* [dadaː] 'o-ow'/ʔəʔəʊ/*(uh-oh* [ʔɛːːʔɛ̆] 'haia' /haɪja/*(hiya)* [hɛja̰]	'ia'/ija/*(yes)* [hijɛ] (2) 'a fi'/avi/*(and me)* [ha̰riː] 'agor'/agɔr/(*open)* [ʔəbu·ɛ̆]
	1;5;19	'o-ow'/ʔəʔəʊ/*(uh-oh)* [ʔaʔəʊ] 'helo'/hɛlɔ/*(hello)* [hɛ̰ju]	'ia'/ija/*(yes)* [hɛɪja]
	1;9;9	'o-ow'/ʔəʔəʊ/*(uh-oh)* [ʔuʔuː](3) 'baby' [beɪbi] 'no no' [na-nəʊ]	'ia'/ija/*(yes)* [ʔɪ·ja] [gija̰] [jɛɪja̰·] [ʔɪjaʔ] [hijaːjɪ] 'yli'/ʌli/*(look at this)* [ʔɒɟi·] [ʔaɟiː] [ʁaliː] [ʔaʌi]

Table 5.9 Word production attempts adapted to CVCV and CVCVCV through onset addition, Welsh environment

Tables 5.10 and 5.11 depict target words produced in the English environment that were adapted to a template containing an onset, with Table 5.10 including those that had CVC and CVCVC word shapes and Table 5.11 including those with a CVCV word shape. Inspection of Table 5.10 revealed that words ending in a coda were produced more often in the English environment (this is discussed further along with percentage frequencies in 5.5, below). There were examples found in each of the sessions analysed for Eve of target words with a CVC shape produced as CVC; these are therefore listed as selected forms. There were also a number of words that Eve produced that were adapted to the CVC template, including her many attempts to produce 'egg' that appeared for the first time at 1;4;28 and then in the 3 subsequent sessions analysed. As she attempted to produce 'egg', a variety of different initial consonants were added, suggesting that she did not demonstrate a preference with regards to the segmental make-up of the added onset. There was only one CVC selected form produced by Beca within the English environment but the English CVC word 'good' was attempted at 1;9;9 in the Welsh environment (see Table 5.8). There was some evidence of adaptation with the name for her doll, 'Annie' being produced with a coda cluster despite the target word ending in an open syllable.

For word production attempts that conformed to the <CVCV> template (Table 5.11), there were some patterns worth noting. Close inspection of Eve's data revealed that the more specific template <dVdV> was being employed, with 'dadda' being selected and then 'it's there' being adapted to [dudɛˑ]. This would also fit the reduplication pattern described in 5.3.4, above. Beca's adapted forms in the English environment are both attempts at 'Annie' [ʔaji] and [ʔaˑɲiˑ]. There are elements of these word production attempts which correspond to two separate patterns within the selected forms identified. Firstly, the glottal stop onset was attributed to a <ʔVCV> template and therefore match with the selected forms for 'uh-oh' [ʔʊʔʊ], [ʔuʔuˑ] and [ʔəʔəʊ]. Secondly, the second consonant, C_2 , was a palatal consonant on both occasions allowing for a <CVC$_P$V> (where C_P relates to a palatal consonant) template to be identified. Her attempts to produce 'hiya' were selected forms [hɛɪjaː], [haɪ̯ja] and [həja], all containing a palatal C_2.

<CVC> <CVCVC>			
		Selected forms	Adapted forms Consonant addition VC → CVC → CVCVC VCV(C) → CVCV(CC) → CVCVCVC
Eve	1;1;21	‘yes’ [jɛtʰ]	‘again’ [hədʲʊdʲɛm]
	1;3;1	‘yes’ [dɛs]	
	1;4;28	‘peg’ [bɛɪk]	‘egg’ [hɛg] [jaç] [hɛgɪt]
	1;7;3	‘shoes’ [ʃuʒ] [ʃiʃ](2) [ʃuʃ] ‘book’ [bʌc](2)	
	1;8;21	duck’ [dʊk](2) ‘cup’ [jɛp] ‘book’ [bʊc](2) ‘shoes’ [ʃuʃ]	‘egg’ [hɛk] [hɛg] [dʲak]
	1;9;21	‘that’ [tat] ‘fish’ [fɪʃ] ‘chick’ [dɪk] ‘house’ [haʊʃ] ‘book’ [bɒk] ‘dog’ [dɒg] mouse [mɔɪç] sheep [ʃɪc] ‘bucket’ [bɪcɛʔ]	‘egg’ [hag] [ʔɛ·k]
Beca	1;2;4	‘horse’ [hɛ̞s̪]	
	1;3;25	‘horse’ [hɔ·s]	
	1;5;19		‘ach’/ax/*(yuk)* [ʔɪːx]
	1;9;9		‘Annie’ [ʔa·ʌɪʇɬ]

Table 5.10 Word production attempts adapted to CVC and CVCVC through onset addition, English environment

<CVCV>			
		Selected forms	Adapted forms
			Consonant addition VC → CV → CVCV V(CC)CV → CVCV VCVCV → CVCV
Eve	1;3;1	'dadda' [dada](2)	
	1;4;28		'egg' [hɛgɛ̰] 'eggy' [hɛgɛ]
	1;7;3		'it's there' [dudɛ·]
	1;8;21	'Bella' [bɛlə̰] [bɛlɛ] [bɛʌa] 'dada' [dada] 'mama' [mama](2)	'another' [nuɗa]
	1;2;4	'baby' [βɛβeɪ] 'hiya' [hə̰ja]	
Beca	1;3;25	'uh-oh' [ʔʊʔʊ] 'hiya' [hɛɪjaː]	
	1;5;19	'hiya' [haɪ̯ja] 'uh-oh' [ʔuʔu·]	
	1;9;9	'baby' [beɪbi] 'hiya' [həja] 'uh-oh' [ʔəʔəʊ]	'Annie' [ʔaji] [ʔa·ɲi·]

Table 5.11 Word production attempts adapted to CVCV through onset addition, English environment

As well as the addition of an onset when attempting words that did not contain one, the children also exhibited patterns of onset omission. In this case, words were adapted to atemplate with no onset, e.g. VCV, with the selected forms being the limited number of target words without an onset that were attempted (see Tables 5.12 and 5.13). Table 5.12 contains the templates found in the samples collected from Gwen and Beca within the Welsh environment. Inspection of this table revealed that Gwen's data did not contain a single selected form conforming to the VCV template. She did, however, omit the onset when attempting the phrase 'ti'n iawn' /tiːnjaʊn/ *(are you alright?)*. For Beca, there were many

examples across the sessions of ‘ia’ /ija/ (yes) being produced which constituted a selected form here, due to the close correspondence between the target and the child’s production. There are also multiple examples of various target words being adapted to this template and therefore produced without their onset.

<VCV>			
		Selected forms	Adapted forms
			Consonant omission CV(CC)CV → VCV
Gwen	1;4;07		‘tiˈn iawn’ /tiːnjaʊn/ *(are you alright?)* [ɪɲaʊ]
Beca	1;2;1	‘iaˈ/ija/*(yes)* [ijɛː]	‘haia’ /haɪja/*(hiya)* [aja](2) [ajə̯] [əɪja] [ajə]
	1;3;20	‘‘iaˈ/ija/*(yes)* [ijaː](2)	‘wow wowˈ*(woof woof)* [ə̯waʊ̯] ‘‘haia’ /haɪja/*(hiya)* [ilʲaː] [ɛɪla]
	1;5;19	‘iˈiaˈ/ija/*(yes)* [ɪʊa]	
	1;9;9	‘oren’ /ɔrɛn/*(orange)* [awɔ] ‘iaˈ/ija/*(yes)* [ija](3) [iˑjaɪ]	‘sori’ /sɔri/*(sorry)* [ɔːwi] ‘dear’ [ijɛˑ]

Table 5.12 Word production attempts adapted to the VCV template through onset omission, Welsh environment

Table 5.13 contains the examples identified within the samples analysed where English was the language of the environment. Here, the examples were not so numerous but adaptation to this template was found across the two children analysed. In a similar way to Gwen, above, Eve did not produce any selected forms that fit this <VCV> template but she did produce ‘hiya’ as [ɛj̯a], therefore demonstrating onset omission. For Beca, there was one selected form recorded, which was the Welsh word ‘ia’ and then two examples of adaptation, the first at 1;2;4 and then again at 1;9;9.

<VCV>				
		Selected forms	Adapted forms	
			Consonant addition	Consonant omission CV(CC)CV → VCV
Eve	1;1;21			'hiya' [ɛja̠]
Beca	1;2;4			'hiya' [ɜ·ja̠ɜ]
	1;3;25	'ia'/ija/*(yes)* [ija]		
	1;5;19			
	1;9;9			'thank you'. [e:ju]

Table 5.13 Word production attempts adapted to VCV through onset omission, English environment

5.5 Coda patterns

The final structural property under investigation was the presence of a coda. The target words attempted were categorised in relation to whether they contained a coda or not. Then, the children's word production attempts were also coded for presence or absence of a coda in order for comparisons with the attempted target word to be made.

5.5.1 Degree of match to target according to word-stage

In the same way as was done for the structural properties already described, adherence to the structural properties of the target words being attempted was investigated. Exploration of the developmental trajectory throughout the single-word stage was done through establishing the degree of match between the children's word production attempts at each word stage and the presence or absence of a coda, as shown in Table 5.14.

Inspection of this table revealed that children produced targets without a coda with greater accuracy overall than targets with a coda, and this was true across both language environments.

WELSH ENVIRONMENT				
Word-stage category	Target without coda		Target with coda	
	n	Match to target	n	Match to target
up to 7	45	90%	0	
8 to 15	18	100%	6	86%
16 to 25	129	91%	36	62%
25+	276	85%	52	45%
ENGLISH ENVIRONMENT				
Word-stage category	Target without coda		Target with coda	
	n	Match to target	n	Match to target
up to 7	42	98%	2	33%
8 to 15	36	95%	37	74%
16 to 24	71	91%	24	63%
25+	158	84%	61	59%

Table 5.14 Number of attempts to produce various target types that matched the target in terms of coda production: Word-stage category comparison

The numbers of targets produced belonging to each category increased over time as the children progressed through the word stage categories. This was true for all except the targets with a coda in the English environment. For the targets without a coda, the percentage match to the target is very high across the first three word stage categories in both language environments with a decrease in accuracy seen for the '25+' category. For the targets with a coda, there is also a decrease in accuracy from the '8-15' to '16-25' to '25+' categories across both language environments. At the first word stage category, there were no targets with codas attempted in the Welsh environment and only two in the English environment.

5.5.2 Word production attempts in different language environments: Between-child comparison

For the final time, a cross-linguistic comparison was made of the numbers of words belonging to each target word category. Target words without codas were more frequently attempted than target words with codas across both language environments, although the difference was more pronounced for the English environment.

Once again, between-child comparisons were made in order to explore the presence or absence of codas as words were attempted across the two language environments. To this

end, all word production attempts were coded in terms of whether they contained a coda and each one was compared to the target word on this basis. Figure 5.7 depicts the proportion of the children's word production attempts that included or did not include a coda, separated in relation to the target word properties. Inspection of this figure revealed that for targets without codas, a large proportion of attempts matched the target in this regard and that the proportions were similar across the language environments. This was not the case for all though, with over 10% of attempts made to produce target words without a coda, containing one nonetheless.

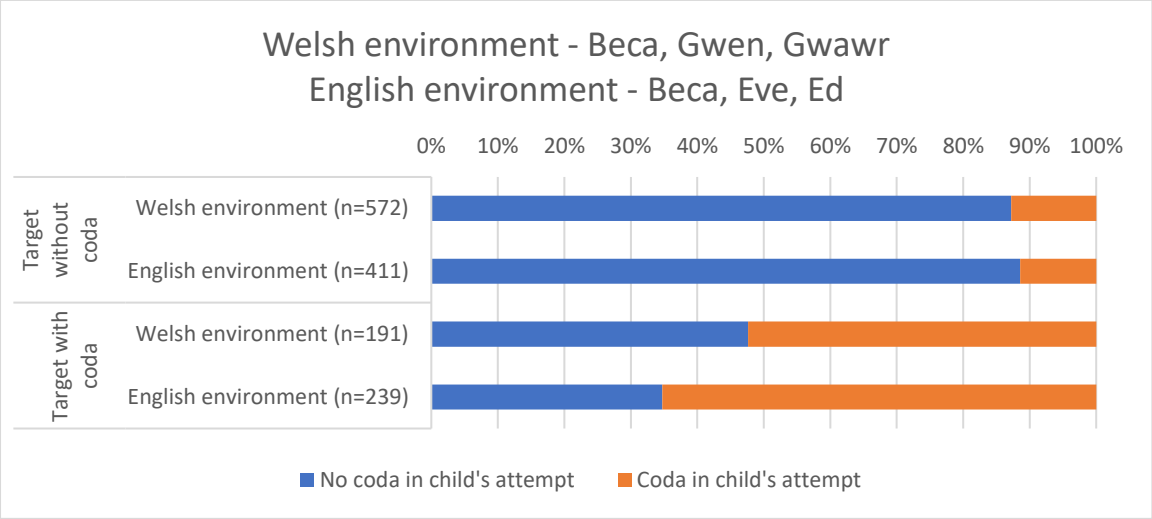


Figure 5.7 Word production attempts with and without codas according to structure of target word: Between-child cross-linguistic comparison

The number of targets attempted with codas was lower overall and the proportions of attempts made with and without codas was different, too. Over 50% of the word-final codas attempted were produced and this was true across both language environments. However, for target words with a coda, a large proportion of word production attempts did not have a coda. Adherence to the coda properties of the target word was higher in the English environment for target words with codas, suggesting that there were fewer occurrences of coda omission.

5.5.3 Word production attempts in different language environments: Within-child comparison

In light of the differences found across language environments within the group data, the data were synthesised in the same way with the analysis being limited to Beca's word production

attempts in order to examine within-child effects. Figure 5.8 depicts her word production behaviour in the presence of target words with and without codas. Inspection of this figure revealed that when attempting targets with codas, Beca produced words without codas at a higher proportion than that seen within the group data above, and this was especially true for the English environment. When the target words did not contain codas, Beca mainly produced attempts that did not, in a similar way to the group values above.

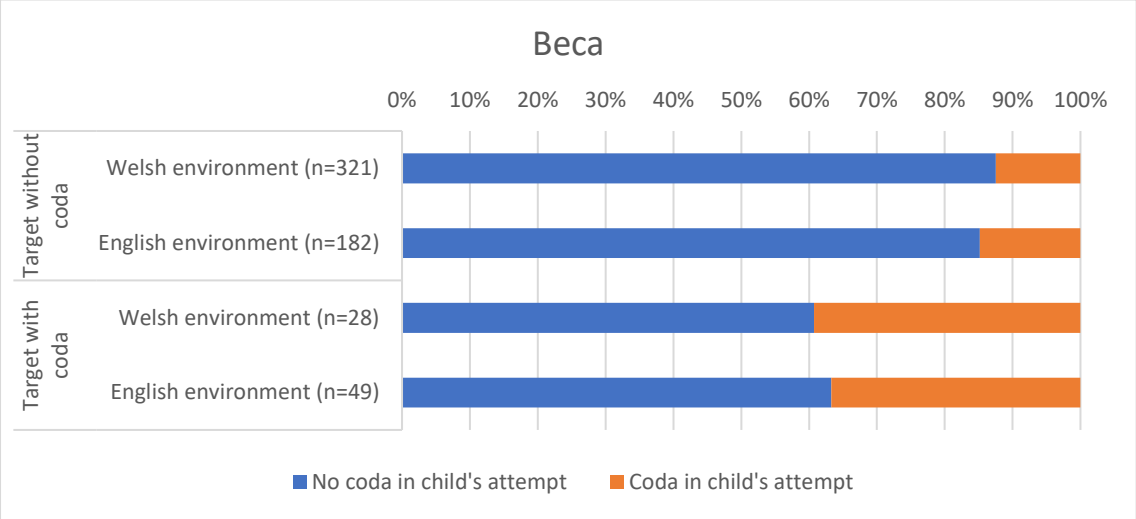


Figure 5.8 Word production attempts with and without codas according to structure of target word: Within-child cross-linguistic comparison

5.5.4 A focus on individual samples: Identification of templates

As already discussed, the presence of a coda within the target word did not always correspond to a coda being produced within the child's attempt. In a similar way to those seen when investigating onset patterns above, these differences gave rise to patterns of consonant omission and addition. For a final time, individual samples collected from the participants were examined in detail and templates were identified. Once again, the analysis was undertaken for Beca, in each language environment, as well as one of the OWH participants, Gwen and one of the OEH participants, Eve.

<CV>					
		Selected forms		Adapted forms	
				Consonant omission CVC → CV	
Gwen	1;1;06	'bw' /bu/*(boo!)* 'go' 'ow' /ʔəʊ/*(oh)*	[β u] [gaʊ] [ʔəʊ]	'dad' /dad/ *(dad)*	[dɛ·ɪ]
	1;2;27	'da' /da/*(tah)* 'dau' /daɬ/*(two)* 'bw' /bu/*(boo!)* 'go' 'ow' /ʔəʊ/*(oh)* 'na' /na/*(no)*	[da](3) [d̥ḁ] [da::] [da:ɪ](7) [daɪ](3) [daɬ] [βu] [gaʊ] [ʔəʊ] [na](5) [ɲa]	'nain' /naɪn/*(grandma)* 'het' /hɛt/*(hat)*	[ɲa:ɪ] [na:ɪ] [ŋaɪ] [hɛ]
	1;4;07	'na' /na/*(no)* 'ow' /ʔəʊ/*(oh)* 'go'	[na:] [ɲa](2) [ŋa] [ʔəʊ](7) [gɔʊ]	'dad' /dad/ *(dad)*	[dɛ·ɪ]
Beca	1;3;20	'yeah' 'da'/da/*(tah)*	[jɛ̰·](2) [dɛ̰:]		
	1;5;19	'ahh' 'ow'/ʔəʊ/*(oh)* 'dau'/daɬ/*(two)* 'ci'/ki/*(dog)*	[ʔa:] [ʔəʊ] [dəu:] [kɨ̰]	'bath' /baθ/*(bath)* 'cath' /ka:θ/*(cat)* 'coed' /kɔɬd/*(wood)*	[ba] [gaʊ] [gɔʊ]

Table 5.15 Adaptation to CV involving word-final coda omission, Welsh environment

In exploring patterns arising from the children's word production attempts not conforming to the coda properties of the target, a number of phenomena were identified. Firstly, words conforming to the <CV> template were amassed, see Tables 5.18 and 5.19. Here, a range of selected forms were identified where the children produced CV targets relatively accurately.

There were many instances of CVC target words being adapted to the CV template across the samples collected from all three children under scrutiny here, and in both language environments.

<CV>			
		Selected forms	Adapted forms
			Word final consonant omission CVC → CV
Eve	1;8;21	'na' [ŋaː]	'gone' [ba]
	1;9;21	'moo' [muː](2)	
Beca	1;3;25	'moo' [mu·] 'no' [nəʊ]	'bowl' [baʊ]
	1;5;19	'yeah' [jɛ](2)	'gone' [hɔ]
	1;9;9	'yeah' [j̥ɛ̥](3) 'oh' [ʔəʊ](3) 'poo' [bu] [bu] '(thank) you' [ju] '(there we) go' [gəʊ](3)	'gone' [gaʊ] [gəʊ](4) [kə̥ʊ̥] [gə](2) [g̥ɒ̥](5) [ga]

Table 5.16 Adaptation to CV involving word-final coda omission, English environment

Where the final consonant of the target word is omitted, this could be described as final consonant deletion (Grunwell, 1987), an example from the Welsh environment being Gwen's (1;2;27) production of nain' /naɪn/*(grandma)* as [naːɪ] and from the English environment, Beca's (1;3;25) production of 'bowl' as [baʊ]. Notably, Beca demonstrated similar application of this template across the Welsh and English environments, but the adaptation was seen slightly earlier in English with the first example in Welsh not being identified until 1;5;19.

A similar pattern of coda omission was identified when words were being adapted to the <CVCV> template (see tables 5.16 and 5.17). Again, all children demonstrated this patterns across multiple sessions and both language environments. Recall from 5.4.4 that a specific template was identified within the <CVCV> word lists, <hVjV>. Close examination of Table 5.17 revealed that Gwen was also adapting target words with codas to this template, with all three examples listed for 1;2;27 demonstrating this pattern.

<CVCV>			
		Selected forms	Adapted forms Consonant omission C(C)V(C)CVC → CVCV VCCVC → CVCV
Gwen	1;1;06	'Peppa' /pɛpa/ [bəʊpa̰]	
	1;2;27	'Cadow' /kadəʊ/ [kadəʊ]	'bron iawn' /brɔnjaʊn/ *(nearly)* [hɪjaʊ] ma'n iawn' /manjaʊn/ *(it's alright)* [hejaʊ](2) 'olwyn' /ɔlwɨn/*(wheel)* [hajeɪ]
	1;4;07	'haia' /haɪja/*(hiya)* [ha̰ja̰] 'hwnna' /hʊna/*(that one)* [hʊŋa] 'Mamow' /maməʊ/ [maməu] 'ta ta' /tata/*(bye)* [t̪ɛt̪a·] 'Peppa' /pɛpa/ [bɛba](2) 'o-ow' /ʔəʔəʊ/*(uh-oh)* [ʔaʔːɔ]	'ma'n iawn' /manjaʊn/ *(it's alright)* [ʔɛŋaʊ] [hijaʊ] 'bib bib' /bibib/*(beep beep)* [bɛbɛɪ] 'see you soon' [sizɪʊ]
Beca	1;2;1	'haia' /haɪja/*(hiya)* [hajɛ](4) 'helo' /hɛlɔ/*(hello)* [hɛl̪ɛ·]	'ceffyl'/kɛfɬl/*(horse)* [dɛdˡa·]
	1;3;20	'dada' /dada/*(dadda)* [dadaː] 'o-ow'/ʔəʔəʊ/*(uh-oh)* [ʔɛːːʔɛ̆] 'haia' /haɪja/*(hiya)* [hɛjă̰]	'cacen'/kakɛn/(cake) [gɛɟa]
	1;5;19	'o-ow'/ʔəʔəʊ/*(uh-oh)* [ʔaʔəʊ] 'helo'/hɛlɔ/*(hello)* [hɛ̟ju]	'mochyn'/mɔxɨn/(pig) [mɛɪhi] 'ceffyl'/kɛfɬl/*(horse)* [ʔiʌ̞u]
	1;9;9	'o-ow'/ʔəʔəʊ/*(uh-oh)* [ʔuʔuːː](3) 'baby' [beɪbi] 'no no' [na-nəʊ]	'bib bib'/bibiːb/*(beep beep)* [bɛ̟ɪβiː]

Table 5.17 Adaption to CVCV involving word-final coda omission, Welsh environment

The previous discussion in 5.3.4 above, is also of relevance here. Recall from Table 5.6 that target words containing codas were adapted to this template through addition of a syllable. Specifically, CVC targets were produced as CVCV.

<CVCV>			
		Selected forms	Adapter forms
			Consonant omission C(C)V(C)CVC → CVCV VCCVC → CVCV
Eve	1;3;1	'dadda' [dada](2)	
	1;7;3		
	1;8;21	'bella' [bɛlạ] 'dada' [dada] 'mama' [mama](2)	
	1;9;21		'two feet' [pu·ŋǐ] 'tortoise' [ʤɔji] [tati] 'snail' [saɪju] 'basket' [bɛku]
Beca	1;2;4	'baby' [βɛβeɪ] 'hiya' [hạja]	
	1;3;25	'uh-oh' [ʔʊʔʊ] 'hiya' [hɛɪjaː]	
	1;5;19	'hiya' [haɪj̈a] 'uh-oh' [ʔuʔu·]	
	1;9;9	'baby' [beɪbi] 'hiya' [həja] 'uh-oh' [ʔəʔəʊ]	'all gone' [ʔɒgɒ]

Table 5.18 Adaptation to CVC involving word-final coda omission, English environment

The omission of the coda present within the target word was not the only pattern seen relating to this structural property. It emerged from the percentage frequency above that a small proportion of target words without a coda were being produced with one nonetheless. It seemed therefore that in a similar manner to the addition of syllables and onsets seen previously in this chapter, coda addition also required further investigation. Close examination of words adapted to the <CVC> template revealed that target words with a CV word shape were being adapted in this way, giving rise to coda addition (see tables 5.19 and 5.20 below). Inspection of these tables revealed that Gwen and Beca demonstrated this pattern, with examples identified within Beca's samples taken in both language

environments. There were no adaptations of this type found in Eve's word production attempts.

<CVC>			
		Selected forms	Adapted forms
			Consonant addition CV → CVC
Gwen	1;1;6	'mam' /mam/*(mum)* [mam]	
	1;2;27	'mam' /mam/*(mum)* [mam](2) 'paid' /paɪd/*(don't)* [bə̰i̯t̪] 'wff' [ʔuɸ]	'ow' /ʔəʊ/*(oh)* [ɹaʊɸ] [jaʊɸ] [ʔɔʊɸ] 'da' /da/*(tah)* [da·tʰ](2) 'na' /na/*(no)* [naʔ]
	1;4;7	'mam' /mam/*(mum)* [maːm](2) [maʊm] [maɪm]	'ow' /ʔəʊ/*(oh)* [ʔəʊɸ]
Beca	1;3;20		'da'/da/*(tah)* [daːʔ]
	1;5;19		'ow'/ʔəʊ/*(oh)* [ʔɛʊɸ]
	1;9;9	'good' [gʊd]	'ow'/ʔəʊ/*(oh)* [ʔɒç] [ʔəʊɸ̆](2) [ʔaʊɬ] [ʔəʊχ] 'no' [nəʊç] 'poo' [βuɸ] 'go' [kə̟ʊ̟x]

Table 5.19 Adaptation to CVC involving word-final consonant addition, Welsh environment

Interestingly, the added consonants were mainly fricatives, with Beca's attempts in particular containing the addition of a fricative coda to various target words across both language environments. For example, she produced 'no' as [nəʊç] and 'go' as [kə̟ʊ̟x] in the Welsh environment. Then in the English environment, she produced 'go' again, this time as [gaʊç]. The selected form in the English environment does contain a fricative coda, so these attempts could be attributed to a <CVC$_F$> template (where C$_F$ refers to a fricative).

<CVC>			
		Selected forms	Adapted forms
			Consonant addition CV → CVC
Beca	1;2;4	'horse' [hɛ̝̊ʂ̺]	
	1;9;9		'(there we) go' [gaʊç] [gəʊɬ] 'oh' [ʔəʊɬ] [ʔəʊɸ] [ʔəʊx] 'yeah' [jaʔ](3) [jɐ̆ʔ] [jɛç] [jɛʔ](2) [jɛ̝ʔ] [ʎaʔ] [ʎɛʔ]

Table 5.20 Adaptation to CVC involving word-final consonant addition, English environment

5.6 Intra-word variability

With the aim of exploring word variability within the single-word period, a variability ratio was calculated for each session (Sosa and Stoel-Gammon, 2006). Due to the naturalistic context in which data collection took place, words were produced at different frequencies. Investigation of word production attempts revealed that while many words were only attempted once during a session, others were subject to a high degree of repetition with Eve, for example, attempting 'egg' 31 times within the session captured when she was 1;4;28.

Recall from section 3.6.4 that a variability was calculated for all words attempted three or more times in the same session. This was done by dividing the number of variant forms with the total number of tokens for that word. The ratios for all eligible words were then combined to give an overall variability ratio for the session. Calculating degrees of variability in this way allowed for investigation of changes in variability over time and across language environments.

The numbers of types, tokens, variant forms and ratios for each child are displayed in Appendix D2 In order to compare degrees of variability across the developmental trajectory, each data point was matched to the nearest month (see Figure 5.9). Inspection of this figure revealed that there was a large amount of individual difference between the children with regards to their intra-word variability. However, it was possible to identify overall trends. The overall variability was relatively high up until 1;6, with some fluctuation seen particularly in the Welsh environment. Gwen's ratio at 1;2;27 was particularly low and inspection of the words produced in that session can offer an explanation. During that session, Gwen attempted 'dau' /dai/ *(two)* 20 times, 18 of which were made up of a [d] onset followed by a vowel (i.e. d+V) and therefore assigned to the same form.

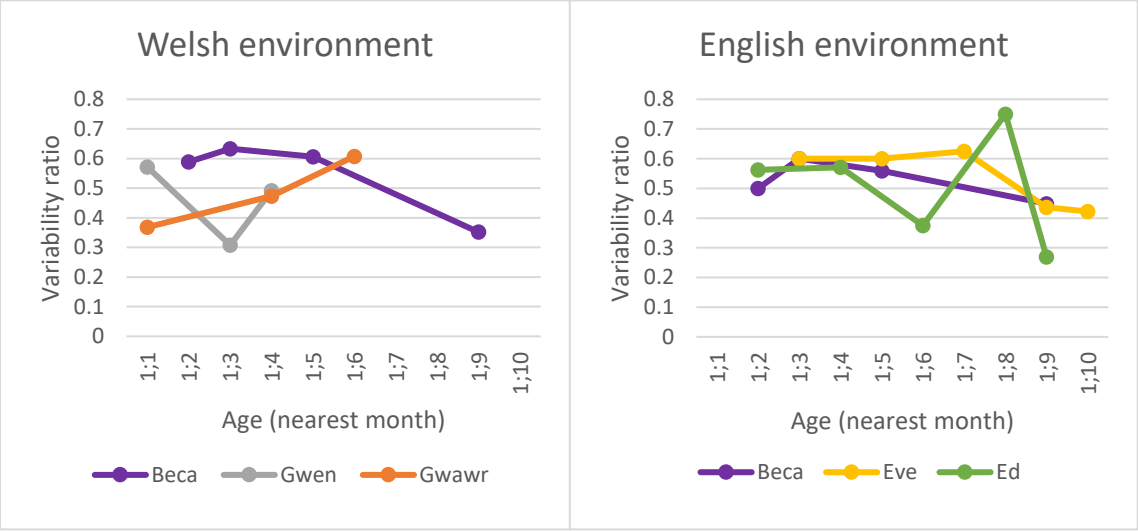


Figure 5.9 Overall variability ratios for each session; Welsh and English environments

There seems to be a decrease in variability after 1;6, with more evidence provided by the sessions captured in the English environment due to the fact that data analysis had come to an end for Gwen and Gwawr. Within the pattern of overall decreasing variability, there was a particularly high ratio recorded for Ed at 1;8;0. Further inspection of the data revealed that Ed only had 2 words that were produced more than three times during this session, 'mummy' and 'way' (a variant of 'yay') and his production was highly variable as he attempted to produce them. For Beca, her variability ratios were similar across the Welsh and English environments, indicating that her word variability did not change according to the language of the environment.

5.7 Discussion

This study explored early speech development in five typically developing children experiencing different patterns of language use within their homes. In this chapter, the focus has been on the study of word production behaviour, with the aim of adding to the findings already presented and discussed in Chapter 4, which focused on consonant development. The variables under examination were the same, namely the developmental trajectory and the role of the ambient language. Detailed analysis of the words produced by children engaged in play activities with their caregivers allowed for further investigation of their speech development. To this end, the target words they attempted were examined and comparisons were made over time and across the language environments. Furthermore, their word attempts were scrutinized in order to investigate the utilisation of their speech production abilities in order to convey meaning. Through this, it was possible to observe the construction and development of the phonological system.

The results revealed, once again, a great deal of cross-linguistic similarity as children produced words across Welsh and English language environments. However, differences did exist that are worthy of further exploration. Target word length and shape was different across the language environments. A larger proportion of words targeted in the Welsh environment were disyllabic and did not contain a coda, whilst monosyllabic words and those with codas were more prevalent within the lexicons of the children captured in the English environment. Similar patterns were also seen in the attempts the children made to produce these target words. Words produced in the English environment were less likely to contain onsets, and where they did, it was less likely that the no onset property would be maintained in the children's word production attempts.

The typically-developing participants of this study were seen to engage in an increasing amount of word production as they got older. As the sessions analysed spanned the single-word period, the findings of this study provide evidence for variable word production during this period, with some evidence for an age-related decrease in variability after 1;6. Where words were compared to their targets based in structural properties, increases and reductions in accuracy were seen that could relate to assertions regarding the underlying learning mechanism and emergence of systematicity (Ferguson and Farwell, 1975; Vihman, 2002; Vihman and Keren-Portnoy, 2013).

In what follows the findings drawn from these results will be discussed and insights drawn in relation to previous literature. Within the first section, 5.7.1, there is a focus on the role of the ambient language and how this can be observed through between- and within-child comparisons. This is followed by a section where the focus is on the developmental trajectory and how this can be observed through investigation of children's word production during the single-word stage.

5.7.1 The role of the ambient language

The most common shapes for target words across both languages were CV, CVC and CV|CV. However, there were cross-linguistic differences in the occurrence of these target words, with CVCV target words being more prevalent in the Welsh environment and CVC target words being more prevalent in the English environment. Studies that have examined differences in the occurrence of target words across different language environments have found cross-linguistic differences in word length and word shape (Vihman, 2000; Khattab & Al-Tamimi, 2013). The recognition of cross-linguistic differences relies on the availability of comparable occurrence data across both languages being studied. For Welsh, there are corpus data available featuring amassed instances of Welsh language, both spoken (Bangor Siarad Corpus, bangortalk.org.uk) and taken from literary forms of the language (Cronfa Electroneg o Gymraeg (CEG), Ellis *et al.*, 2001). However, frequency data relating to the frequency of particular segments and syllabic structures are not available.

There is a report which features data from five Welsh-speaking children, aged between 1;2;24 to 1;6;18, who are deemed to be at the 25-word-point (Vihman, 2000). This report includes data on the structure of the Welsh target word attempted by this group. Table 5.21 depicts the syllable number data alongside comparable data from the participants of this study. Inspection of this table revealed that the cross-linguistic differences identified here are in line with Vihman's (2000) data, but there are some differences. In Vihman's study, the Welsh-speaking children attempted a substantially higher proportion of di- and multisyllabic target words than the English-speaking children, and the converse was true for the monosyllabic targets. In this study, however, a more balanced distribution of target word lengths was seen within the Welsh environment. In the English environment, a preference for monosyllabic targets was apparent, especially when all sessions were taken into account.

Welsh environment			
	Vihman (2000), 25-word-point	This study, all sessions	This study, '25+' word-stage category
Total target words attempted	265	818	321
Monosyllabic target	97 (37%)	415 (51%)	147 (46%)
Disyllabic or multisyllabic target	168 (63%)	403 (49%)	174 (54%)
English environment			
	Vihman (1996 cited in Vihman, 2000), 25-word-point	This study, all sessions	This study, '25+' word-stage category
Total target words attempted		710	243
Monosyllabic target	Mean 67%	443 (62%)	144 (59%)
Disyllabic or multisyllabic target	Mean 43%	267 (37%)	99 (41%)

Table 5.21 Comparison of target word syllable number data with Vihman (2000); Welsh and English environments

One reason for the difference could be that the cross-linguistic differences are more apparent when data from children learning Welsh are compared to children learning American English, as was the case in Vihman's (2000) study. As the children in this study are being exposed to a contact variety of English, Welsh English, the cross-linguistic differences may not be so apparent due to structural convergence leading to greater similarity between Welsh and Welsh English (Mennen *et al.*, 2020). It is also worth noting that there were methodological differences between the study reported in Vihman (2000) and the study reported in this thesis. With the aim of avoiding over-representation of structural patterns in the occurrence data, target word types were used within the calculations reported here. In Vihman's (2000) study, percentage occurrences were based on target word tokens which means that repeated attempts made by a child to produce a particular target word would have been included in the occurrence values. This could be the reason for the starker differences between Welsh and English they reported.

The presence or absence of onsets and codas within target words was also under scrutiny within the study presented in this thesis. Findings indicated that there was a greater

prevalence of targets without onsets in the Welsh environment and a greater prevalence of targets with codas in the English environment. In Vihman's (2000) study, the proportion of words with onsets attempted was similar across the data from the Welsh and English groups depicted. However, a lower proportion of target words attempted by the Welsh-speaking children contained codas, which supports the findings reported here that target words with codas are more prevalent in the English environment.

Early word production has been compared by a number of researchers and findings have provided evidence for universal as well as language-specific influences (Fagan, 2009; Menn and Vihman, 2011). Sessions being captured across two language environments allowed for cross-linguistic comparisons to be made. In line with the findings that related to consonant development presented in Chapter 4, there was overall similarity seen across the Welsh and English environments in terms of the word production behaviours identified. The proportions of mono- and di-syllables produced by both groups were similar as was the incidence of syllable addition and omission.

The inclusion of a child who was experiencing dual home-language input allowed for within-child cross-linguistic comparisons to be made. Beca's data were in line with the group comparison for syllable number but this was not the case where onset and coda patters were concerned. The group data show a cross-linguistic difference whereby a higher number of targets without onsets are produced without onsets in the Welsh environment. However, Beca's production patterns for targets without onsets were similar across both her language environments. For attempts made to produce target words without a coda, the group values showed a slightly higher proportion of attempts made in the Welsh environment being produced without a coda. Again, Beca's production patterns for targets without a coda were similar across both language environments. This suggests that Beca is applying similar modification processes across Welsh and English and her vocal behaviour is not in line with her peers' who are residing in single-language homes. These findings therefore provide support for the notion that dual-language exposure results in interaction between emerging systems (section 2.4.1).

5.7.2 Word production over time

There was overall growth in the number of words produced per session both in relation to types and tokens. This is in line with expectations at this stage of development (McCune and Vihman, 2001; Stoel-Gammon, 2011). Many of the word production attempts made related to the same target word as the children began to influence the world around them using their speech production abilities. In general, there was a fair degree of variability seen for all children throughout the period which corresponds to the single-word stage. Although the pattern is not neat, there was an overall tendency for decreased variability after 1;6 when first words are established. Variability in word production can lead to limited intelligibility and reduced communicative potential and is of particular relevance when investigating speech production within clinical populations (Dodd, 2005). Some studies focusing on inconsistency and variability in word production show an increase in variability towards the end of the single-word stage, which coincides with lexical growth (Sosa and Stoel-Gammon, 2006). Other reports suggest that word variability decreases as a child gets older (Burt *et al.,* 1999). Various influencing factors have been suggested including neuromotor control and those surrounding the development and organisation of the phonological system (Sosa and Stoel-Gammon, 2006). These factors are not seen to be language-specific; therefore, it is unlikely that the language of the environment has a bearing on the patterns of word variability. This is in line with the findings of this study where it was not possible to identify cross-linguistic differences and therefore it did not appear that variability was influenced by the language of the environment.

For words where a conventionalised gloss could be attributed, the developmental trajectory was also explored through comparing the children's attempts with their targets on the basis of the three structural properties under investigation. Where sessions were grouped according to word-stage category, it was possible to identify trends as the children moved through the single-word period. For syllable number, there was a decrease in the degree of match to target for monosyllabic and disyllabic targets. In the English environment, the structural accuracy of attempts made at mono- and disyllabic targets decreased steadily between the first three categories, with increased accuracy apparent by the fourth word-stage category, '25+'. In the Welsh environment, this trend was not so clear; however, there was a pattern of earlier sessions being more accurate than later sessions. Within the literature, assertions have been made regarding a U-shaped developmental trajectory for accuracy, with first words

being relatively closely matched to their targets, followed by a period of decreased accuracy before increased accuracy once again as children begin to systematise their phonological knowledge and substitutions seem to be made on a more segmental basis (Vihman, 2017). Where adherence to the target was judged with regards to the presence or absence of a coda, the findings revealed that target type had a bearing on the accuracy patterns seen. For targets without a coda, the percentage match to target tended to be high and only a slight decrease was seen across the data collection period. For targets with a coda, a steady decrease in accuracy was seen with sessions featuring a higher number of word types featuring a higher proportion of targets with a coda being attempted and not produced as such. Final consonants appear less frequently in the speech of younger children (Robb and Bleile, 1994) so in the context of a U-shaped curve, it could be that by the final word-stage category, the increase in accuracy had not begun in relation to this structural property.

Evidence was provided for the use of templates across the three children investigated in this chapter: Beca, Gwen and Eve. Close inspection of the words they produced within their sessions spanning the single-word period led to the identification of selected and adapted forms which illustrated how familiar motoric routines had been utilised in both language environments for the production of novel words. Previous studies that have provided evidence for the templatic approach have sought to ascertain the age at which the process of adaption began along with the suggestion that this should be taken as a marker for the emergence of a phonological system (e.g. Velleman and Vihman, 2002; Vihman and Croft, 2007). Examples given would include selected forms identified within earlier sessions alongside their adapted counterparts taken from later sessions. In the study reported here, this pattern was seen for some of the templates identified within the data collected from all three children. However, selected and adapted forms belonging to the same template were also identified within the same session, with earlier sessions not featuring these word production patterns. Furthermore, there were some occasions where adapted forms were actually identified at an earlier age to their selected counterparts. The templatic approach has provided a useful framework for the study of word production at this stage in development, but due to the sequencing of selected and adapted forms not always following what has been previously reported in the literature, the framework may need to be extended to account for these patterns.

The purpose of this chapter was to present and discuss the results of this study pertaining to word production within typical development. Data from five of the six participants were presented and the vocalisations they produced with the intent to convey meaning were examined in relation to the words they were targeting and the patterns employed as they were attempted. The next chapter will focus on the data collected from Ben, who was identified as displaying atypical speech and language development around the time of his second birthday. Data gathered from the typically-developing (TD) group relating to consonant (Chapter 4) and word (Chapter 5) production will be used for comparison.

6 Consonants and early words production in atypical development: a case study

6.1 Introduction

In Chapters 4 and 5, the vocal productions of five typically developing children were investigated in detail. Several sessions that had been recorded at regular intervals were chosen for analysis as they spanned the time period denoted as the single-word stage. There is a great deal of variation across individual children in the rate of lexical development at this time. All children were recruited around their first birthday and data analysis continued for each child until they had reached the 25-word-point, where they were thought to have approximately 50 words in their lexicon (DePaolis, Vihman and Kunnari, 2008; Kunnari, 2002; Vihman, 1993; Vihman and Velleman, 2000). Although this point came earlier for some children than others, all five of the children already discussed had reached this point by the time they were 1;9;21. This was not the case for the sixth participant, Ben, whose data will be the focus of this chapter.

Recall from 3.4 that Ben was recruited in the same way as the other children around the time of this first birthday. He was the second of two boys and was residing within a bilingual household in which his mother spoke to him in Welsh while his father spoke to him in English. Both his parents were Welsh-English bilingual speakers and had grown up in the same area of North-West Wales where they now resided. As is also detailed in section 3.4, as data collection progressed, it seemed that Ben's speech and language development was lagging behind that of his peers, and his parents became concerned. This led to a referral to the local Speech and Language Therapy department, just before his second birthday. During data analysis, there were indications that Ben's speech and language development was not following the expected trajectory and this, together with the fact that he had been identified as having speech and language difficulties, led to the separate consideration of his data in the form of a case study. His vocal productions had been recorded from an early stage, prior to the raising of any concerns regarding his speech and language development. This offered a rare opportunity to investigate the production of consonants and early words by a child that was later deemed to be demonstrating atypical speech and language development.

The single-word-period will remain the focus of investigation. Four sessions in each language environment were analysed in detail and Ben's abilities were explored in terms of consonant and word production. Consequently, both segmental and structural aspects were investigated in order to highlight the differences between his abilities and those of the other children. Within-child cross-linguistic comparisons were also undertaken with a comparison of Ben's productions in each of his language environments. This allowed for exploration of systemic separation and interaction, within the context of atypical development.

The chapter begins by reporting on Ben's stages of development, including a description of his lexical development across the data collection period and an illustration of how this fits with the word-stage categories that were devised to enable comparison across the children. There are then three sections (sections 6.3 - 6.5) that report on consonant development and therefore relate to what was reported in Chapter 4 in relation to the five participants that belonged to the typically-developing (TD) group. In section 6.6, the focus moves to word production with the occurrence and variety of words being produced in each session being examined along with the word shapes of the target words attempted. Sections 6.7- 6.9 then relate to the same three structural properties that were examined in Chapter 5 in relation to the TD group: syllable number, onset patterns and coda patterns. Ben's multiple attempts to produce the same target word were investigated in relation to variability, this is reported in section 6.10. The chapter ends with a discussion of the main findings derived from the data depicted within the chapter.

6.2 Ages and stages

A total of 3093 vocalisations were captured and analysed across the 8 sessions that were subjected to detailed analysis. There was a general increase in the number of vocalisations produced as Ben got older, in a similar way to that seen for the other 5 children (see appendix D1 for the numbers of vocalisations across all analysed sessions, including those involving Ben). The numbers of vocalisations identified as words also increased as the children progressed through the single-word-period, although the atypical nature of Ben's lexical development was apparent due to the protracted length of time he took to reach the 25-word-point (see Figure 6.1). Inspection of this figure revealed that there was variation in the number of word types produced by each child, as compared by age (see section 5.2.1 for

further discussion of participants from the TD group). Despite this variation, all five of the children had produced at least 25 words within the 30-minute session by the time they were 1;9;21. Viewing the number of words produced by Ben across the different ages alongside those belonging to the TD group meant Ben's deviation from the typical trajectory could clearly be seen.

In the Welsh environment, Ben was 2;5;16 when he produced 25 word types within the 30 minute session. However, in the English environment, Ben only produced 20 word types within the final session, recorded when he was 2;5;19. His rate of development, therefore, was not commensurate across the two language environments. It took him until he was almost two and a half to reach the end of the single-word period in Welsh, but the same point had not been reached in English. By this point, his lack of vocabulary development had prompted a referral to Speech and Language Therapy services leading to the confirmation by professionals that Ben's speech and language development was not following the expected trajectory.

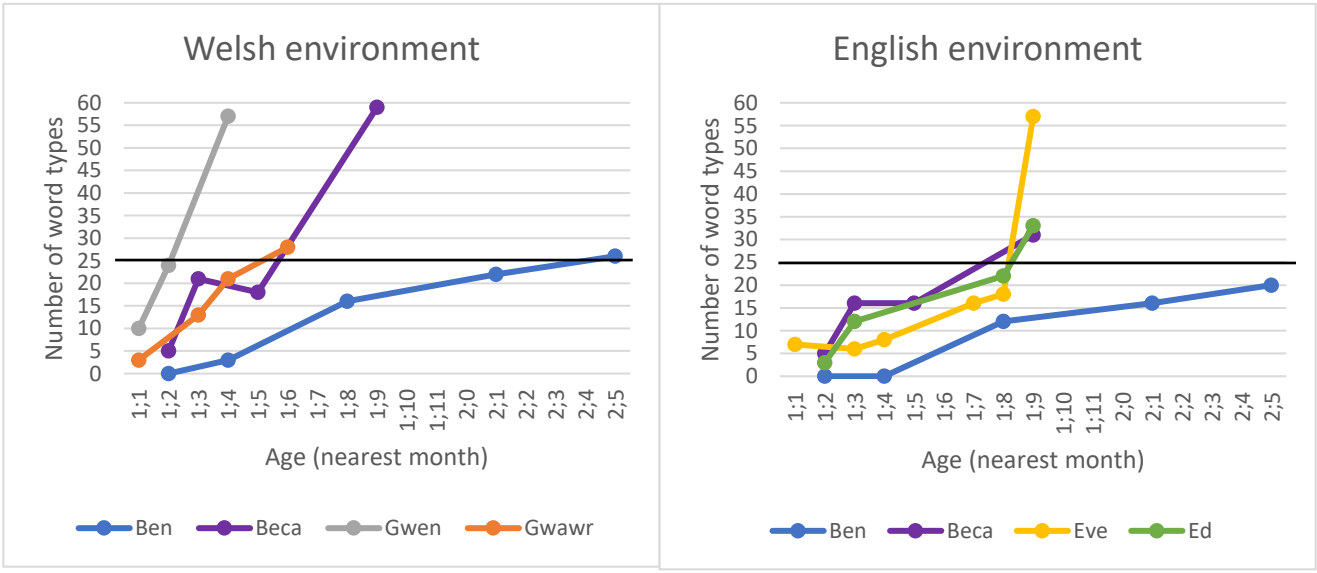


Figure 6.1 Number of word types produced in each 30-minute session. Black line marking the 25-word-point and the end of the single-word-period

Recall from section 4.2.1 that where group values were compiled, sessions were matched on the basis of the number of word types produced. This gave rise to word-stage categories which spanned the single-word period. Table 6.1 shows how Ben's analysed sessions were mapped onto the word-stage categories, with figures related to the TD group provided for comparison. It can be seen through inspection of this table that for the first word-stage category 'up to 7', only a Welsh environment session was analysed. During the same week,

at 1;4;10, Ben was captured in an English environment, engaging in play with his father. Although he produced 129 vocalisations, none of them met the criteria for word classification and therefore his first analysed session in English could not be assigned to a word-stage category, suggesting that at that point he had not yet commenced the single-word stage. The second of Ben's English environment sessions to be analysed was captured around four months later and by that point, he was firmly in the single-word period, with 12 word types produced in 30-minutes. Assigning word-stage category labels to Ben's data allowed for comparison with the TD group on the basis of lexical development. It was interesting to see that whilst the other children generally moved through the word-stage categories fairly quickly, Ben's lexical development could be described as belonging to the 16 to 24 word-stage category for a period of 4-5 months. Despite his analysed sessions being spaced further apart than the ones featuring participants from the TD group, there were two sessions where he produced between 16 and 24 word types in each of his language environments. Furthermore, as his lexical development was not even across the two language environments, he would be described as being at this stage of lexical development at different ages.

Word-stage category	Up to 7		8 to 15		16 to 24		>25	
	Age	Word types	Age	Word types	Age	Word types	Age	Word types
Welsh environment								
Ben	1;4;17	3			1;8;09 2;1;09	16 22	2;5;16	26
TD children	1;1;7-1;2;1	3-5	1;1;6-1;3;1	10-13	1;2;27-1;4;13	21-25	1;4;7-1;9;9	30-57
English environment								
Ben			1;8;06	12	2;1;08 2;5;19	16 20		
TD children	1;1;21-1;2;17	3-7	1;3;25-1;4;28	8-15	1;5;19-1;8;10	16-22	1;9;9-1;9;21	31-60

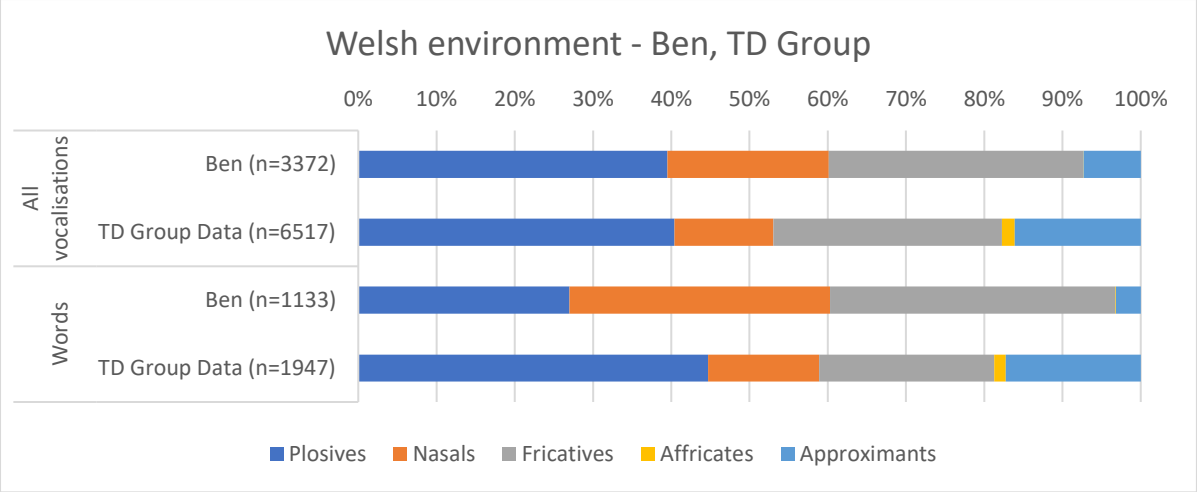
Table 6.1 Mapping Ben's sessions according to word-stage category

6.3 Consonant development

6.3.1 Frequency of consonant production by manner

In the same way as in Chapter 4, where the focus was on the TD children, consonant production was first explored by categorising each of the consonants produced in terms of their manner of articulation. The percentage frequencies of consonants belonging to each manner category across all vocalisations produced across all sessions are depicted in Figure 6.2. Within this figure, the percentages amassed from Ben's sessions are compared to those of the TD group. Inspection of this figure revealed that the proportions of manner categories were fairly similar to those produced by the TD children. Taking all vocalisations into account in the first instance, plosives were the most prevalent, followed by fricatives. For the TD group, the other three manners were produced at substantially smaller proportions with approximants being the next most prevalent, followed by nasals and then a very small percentage of affricates. The sessions captured in an English environment featuring the TD children contained similar proportions of the manner categories, following the same sequence from most to least prevalent. For Ben, the nasals were far more prevalent than the approximants, especially in the Welsh environment. Affricates were produced at a very low proportion across both language environments.

Looking at the subset of vocalisations identified as words, the TD group again showed a preference for plosives, which were produced at a similar proportion to that seen in all vocalisations. The other categories followed the same order of frequency as that seen in all vocalisations, with fricatives being the next most prevalent followed by approximants, nasals then affricates. Conversely, the manner category produced at the highest frequency in words for Ben was fricatives, followed by nasals then plosives. The difference between Ben and the TD group was more noticeable in the Welsh environment but his preference for fricatives as he produced words was also apparent across the sessions captured in the English environment.



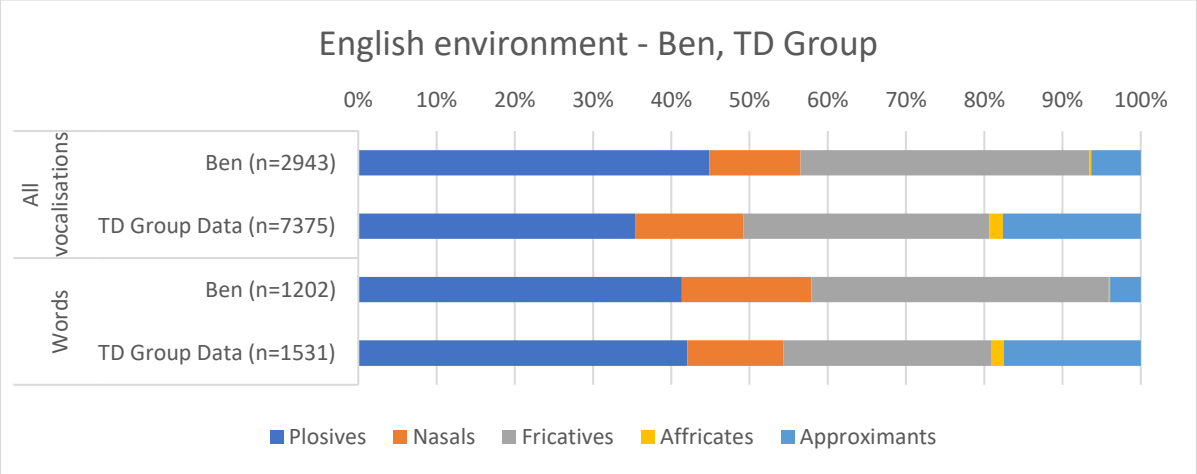


Figure 6.2 Frequency of occurrence of manner categories across all vocalisations and all session; Ben and TD group comparison, Welsh and English environments. Total number of consonants produced depicted as n-value.

The prevalence of consonants belonging to each manner category across all recorded sessions provides an insight into the nature of consonant production within the single-word period. But a great deal of development happens as children move from producing their first words to having a lexicon containing approximately 50 words. In order to investigate how the nature of the consonants produced changed over time, the proportion of consonants belonging to each manner category was calculated separately for each session. These investigations were also undertaken for the TD group and reported in Chapter 4. Recall that sessions involving different children that belonged to each word-stage category were grouped together and compared. It was reported in sections 4.3.1 and 4.3.3 that the proportions of consonants produced remained relatively constant across the four word-stage categories. The nature of consonant production was investigated across Ben's four analysed sessions, with consonants categorised according to manner of articulation (see Figure 6.3). Inspection of Figure 6.3 revealed that the proportion of affricates and approximants remained constant across the four sessions and that of nasals was constant for the first three sessions before a rise was seen,

which was particularly pronounced in the Welsh environment. The proportion of plosives began very high in both languages and showed a decline as Ben got older. The converse was seen for the fricative category which showed an overall rise across the first three sessions, followed by a slight reduction.

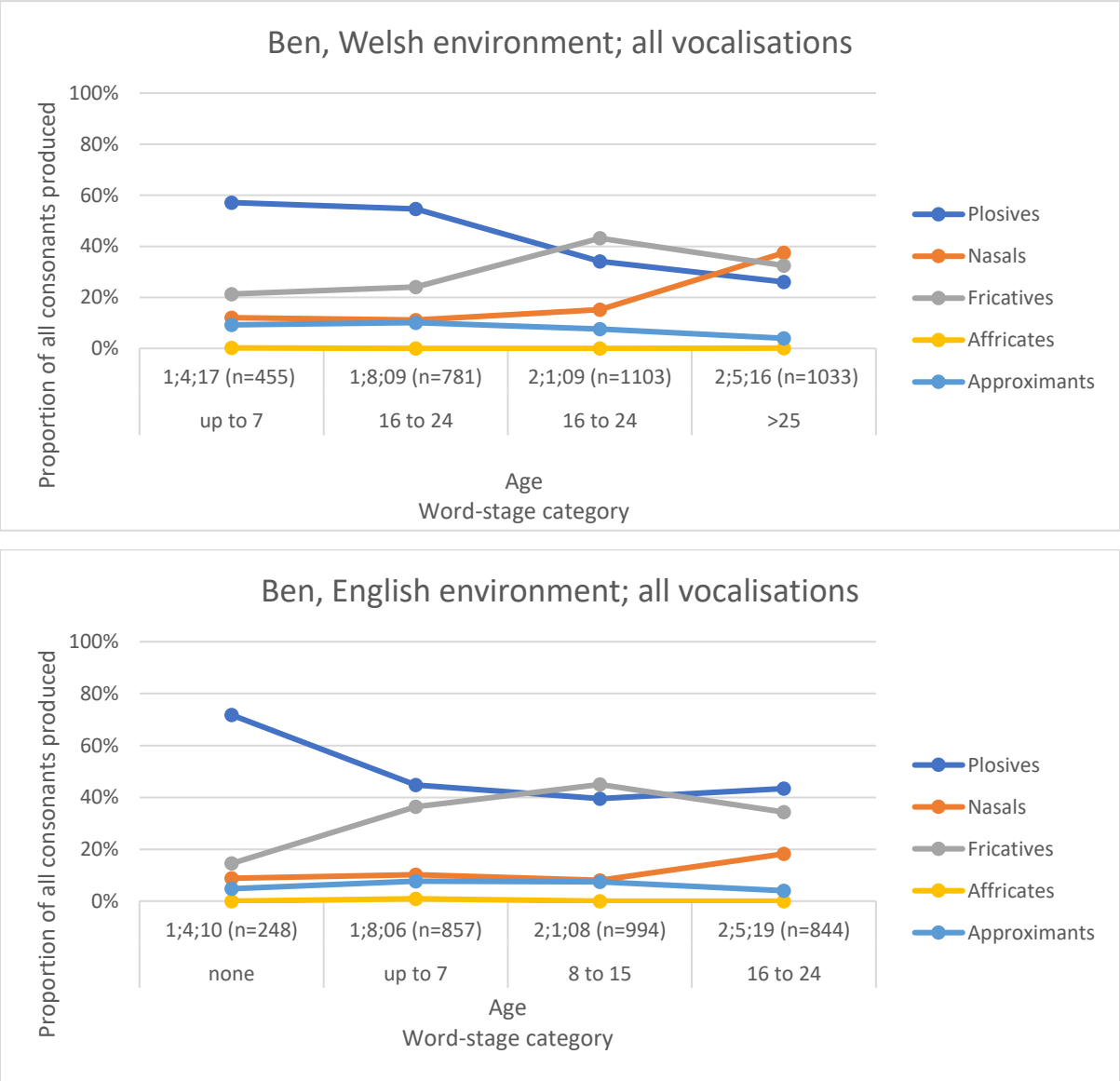


Figure 6.3 Changes in the proportion of consonants produced belonging to each manner category across all vocalisations, Welsh and English environments. Sessions depicted in sequence and labelled according to age and word-stage category.

6.3.2 Frequency of consonant production by place

The nature of consonant production was then explored by categorising each of the consonants produced in terms of their place of articulation. Having reported on this type of analysis in

Chapter 4 for the TD children, Ben's data were analysed in the same way to allow for comparisons to be drawn. To this end, the proportions of consonants belonging to each place category that were produced by Ben and the TD group are depicted in Figure 6.4. Inspection of this figure revealed that Ben's consonant production differed considerably from the TD group in terms of place of articulation. The Welsh environment data show that Ben produced a high proportion of consonants at labial and post-velar places of articulation, with the totals of the other three categories amounting only to 17% and 20% of the consonants produced across all vocalisations and words respectively.

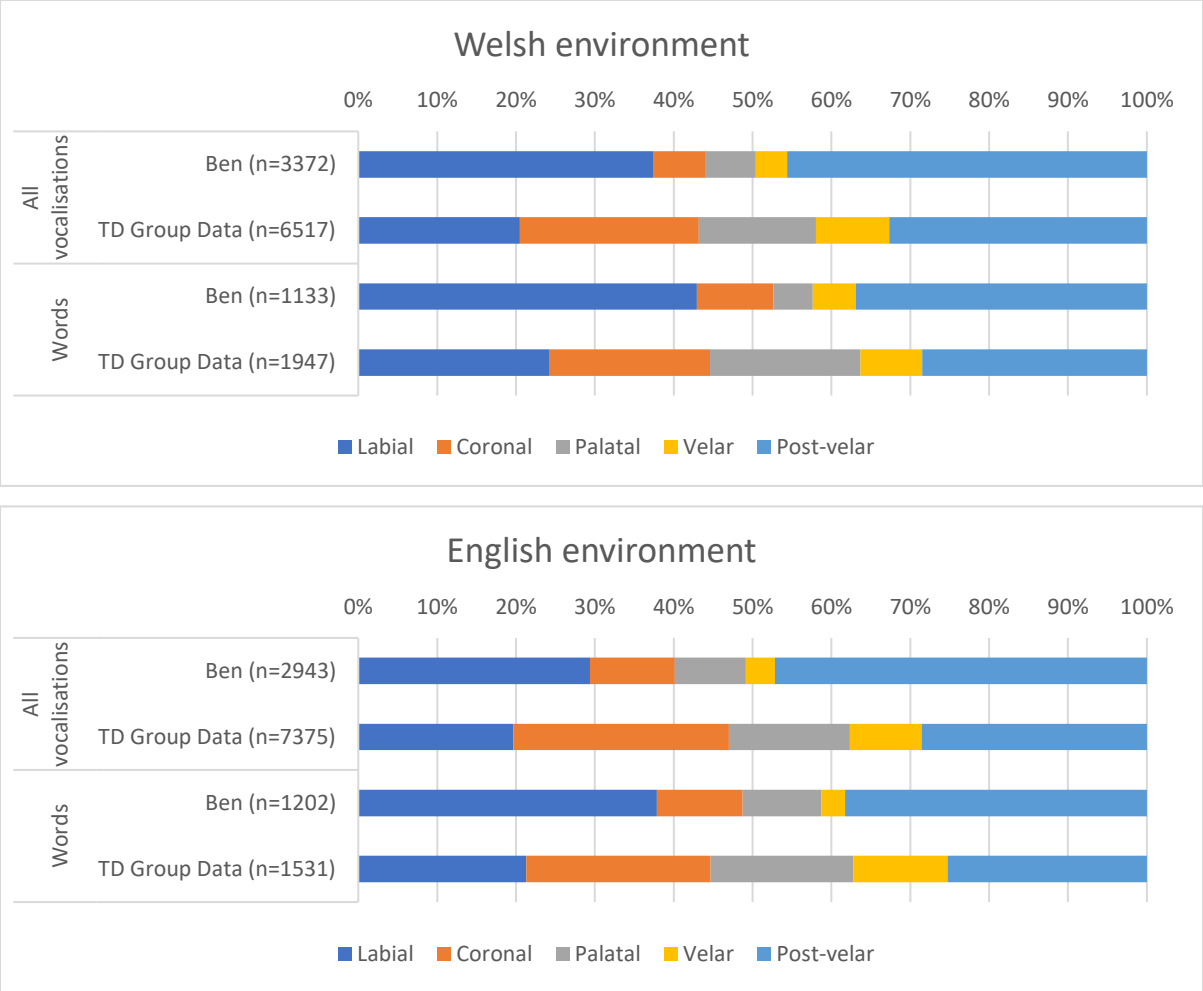
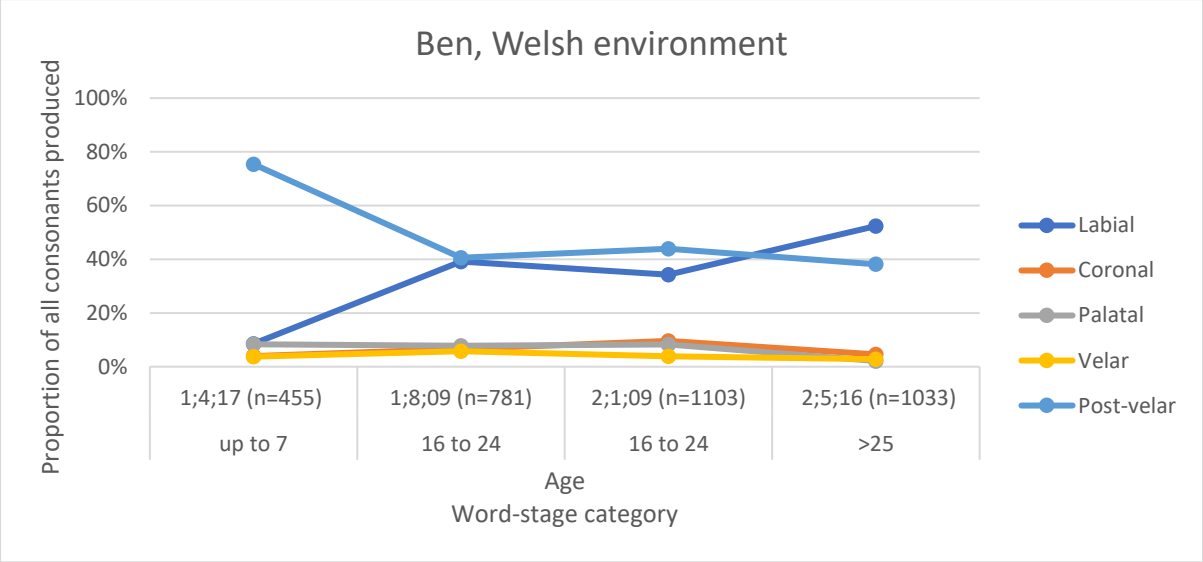


Figure 6.4 Frequency of occurrence of place categories across all sessions, Welsh and English environments. Depicted separately for all vocalisations and words; Ben and TD group comparison. Total number of consonants produced depicted as n-value.

This was not the case for the TD group where coronal and palatal consonants were produced at a higher proportion. In the English environment, a similar pattern was seen with a

preponderance of labial and post-velar consonants. Comparison across the Welsh and English environments demonstrated high within-child cross-linguistic similarity.

In the same way as was done for manner of articulation, the frequency of occurrence of consonants belonging to each place of articulation category was calculated separately for each session in order to investigate changes over time (see Figure 6.5). Inspection of this figure revealed that the less prevalent place categories, namely coronal, palatal and velar, remained fairly constant over the four sessions. However, for consonants that had a labial or post-velar place of articulation, there was a substantial change seen across the single-word period, with an increase in the proportion of labial consonants coinciding with a reduction in the proportion of post-velar consonants produced. These trends were seen across both language environments, and the similarity was more apparent when word-stage category was compared rather than age. Consequently, for the second and third session in the Welsh environment, the category proportions are similar to the fourth session in the English environment.



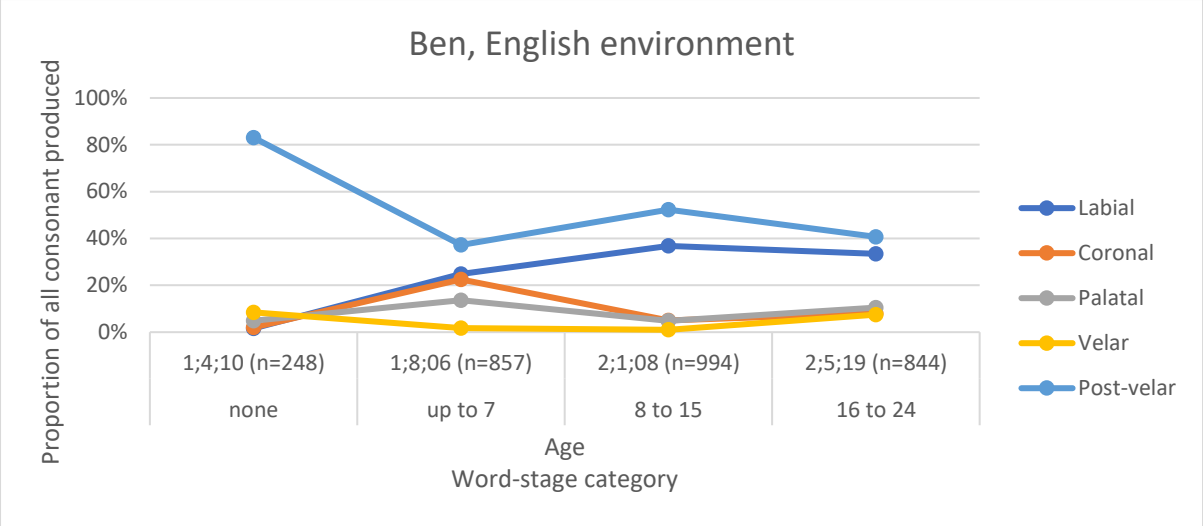


Figure 6.5 Changes in the proportion of consonants produced belonging to each place category across all vocalisations, Welsh and English environments. Sessions depicted in sequence and labelled according to age and word-stage category

6.4 Preferred sounds produced in all vocalisations

Having investigated the nature of consonant production in terms of manner and place, Ben's production of individual consonants was then examined. Inventory size is discussed in the next section (6.5.1) but here the focus is on the relative frequencies of individual sounds within the inventory.

In the same way as was done for the TD group, the occurrence of each sound across all consonants produced was calculated and those sounds with an occurrence of more than 10% were labelled *preferred sounds* (Amayreh and Dyson, 2000). A further subgroup was identified of sounds produced with an occurrence of more than 20%, these were labelled *highly preferred sounds* (see Table 6.2).

Over-reliance on one or two sounds leads to vocal output that is repetitive and lacking in variation. When all vocalisations are considered, regardless of their lexical status, it is possible to draw conclusions regarding motoric preferences. In order for the necessary explicit learning to be taking place for the development of a phonological system, a variety of movements need to be implemented. Preference for certain consonants may impede this process and the presence of preferred sounds is not commonplace in typical development (Amayreh and Dyson, 2000). Indeed, the typically developing children in this study had

Welsh environment				
	Consonant tokens produced	Percentage occurrence		
		5-10%	>10-20%	>20%
1;4;17	455	m j	h	ʔ
1;8;09	781	j	h	b ʔ
2;1;09	1104	m j	b ʔ	h
2;5;16	1033	ʔ	b	m h
English environment				
	Consonants produced			
		5-10%	>10-20%	>20%
1;4;10	248	ŋ	h	ʔ
1;8;06	857		ʔ d b	h
2;1;08	994	m	ʔ	b h
2;5;19	844	c	b ʔ m	h

Table 6.2 Often occurring sounds grouped according to frequency; Ben, Welsh and English environments

relatively spread inventories with individual sound occurrence not exceeding 20% in 16 of the 26 sessions captured, see Figure 6.6. Where there was a highly preferred sound identified, it was the only sound produced with this degree of frequency. Conversely, Ben's output in every session was dominated by a small set of sounds, with all analysed sessions containing at least one highly preferred sound.

Figure 6.6 Consonant with >20% occurrence across all vocalisations, Welsh and English environments

Furthermore, three of his sessions (two in the Welsh environment and one in the English environment) contained two of these highly preferred sounds, each amounting to over 20% of the total consonants produced. This was not seen in any of the sessions recorded with the typically developing children. Inspection of Figure 6.6 also revealed that for Ben, his highly

preferred sounds amounted to a substantial proportion of the total consonants produced. This was particularly apparent for [ʔ] at 1;4, which was produced at 56% and 69% in the Welsh and English environments, respectively. The dominance of this consonant at this age was far higher than that seen for any in the TD group, whose preferred sounds amounted to a maximum of 37% with many of the values being between 20-30%.

6.5 Rate of consonant development

6.5.1 Inventory size across all vocalisations

The number and variety of consonants produced by a child increases as they get older and gain a greater amount of control over their articulators (Stoel-Gammon, 1985; see section 2.3.3). The rate of consonant development as illustrated by growth in the size of the consonant inventory was depicted in section 4.5.1 for the participants belonging to the TD group. In Figure 6.7 below, these figures are depicted again, alongside the number of consonants present in Ben's inventory at each age, for comparison. Examination of the figure revealed that from the outset, Ben did not produce as wide a range of consonants as the other participants. Also, his inventory did not grow to be as large and that there was a decrease in the size of his inventory post 1;7. In the Welsh environment, the size of Beca's, Gwawr's and Gwen's inventories showed a steady increase throughout the data collection period.

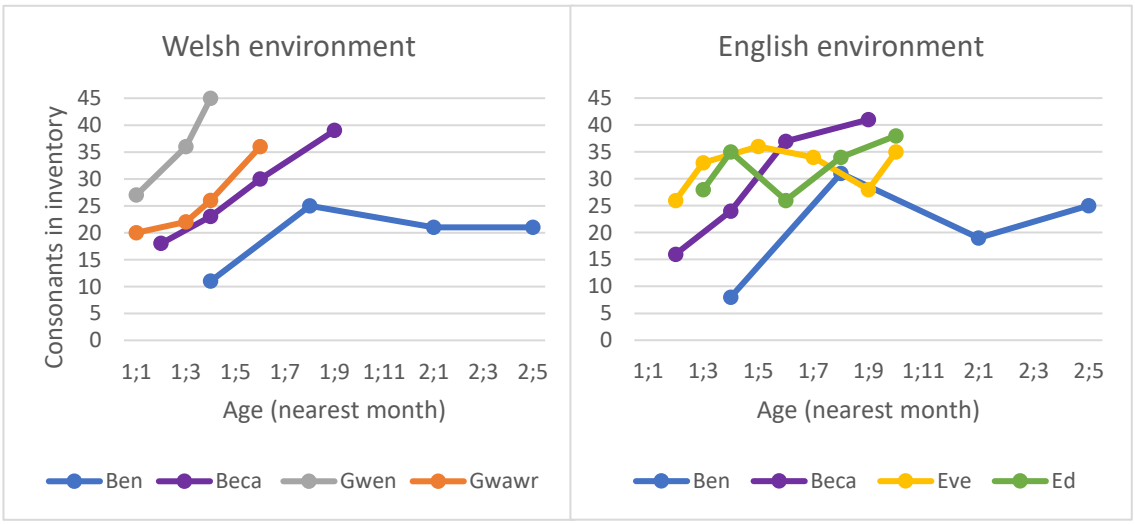


Figure 6.7 Size of consonant inventory at each data point, analysis of all vocalisations produced, Welsh and English environments

In the English environment, the size of Ben's inventory at 1;8 was more similar to that of his peers with numbers of consonants present ranging from 31 to 34 for Ben, Eve and Ed. However, whilst the inventories compiled for the other children continued along a growth trajectory with Eve's and Ed's inventories containing 35 and 38 respectively at 1;10, there was a sharp decline in the number of consonants present in Ben's trajectory with 19 recorded at 2;1 and 25 at 2;6. It is important to remember that although Ben's analysed sessions span a larger timeframe, they represent the same period in term of lexical development.

Recall from 4.5.1 that close examination of the data revealed that the size of the inventory recorded for a particular session seemed to be related to the number of vocalisations produced. In order to examine whether this was the case for Ben, the number of vocalisations produced during each data point was compared to the number of consonants included in his inventory (see Figure 6.8). Examination of this figure revealed that the decrease in inventory size seen for Ben did not coincide with an overall decrease in the number of vocalisations produced. In both language environments, there was a steady increase in the number of vocalisations produced during the first three sessions, up until 2;1 but a reduction in the size of the inventory between 1;8 and 2;1. Ben produced fewer vocalisations in the final recorded session, at 2;5, in both language environments than the previous session analysed but his volubility was similar than that seen at 1;8. The data reveal a decrease in the size of his inventory however suggesting a decrease in the variety of consonants produced as he got older and proceeded through the single word stage.

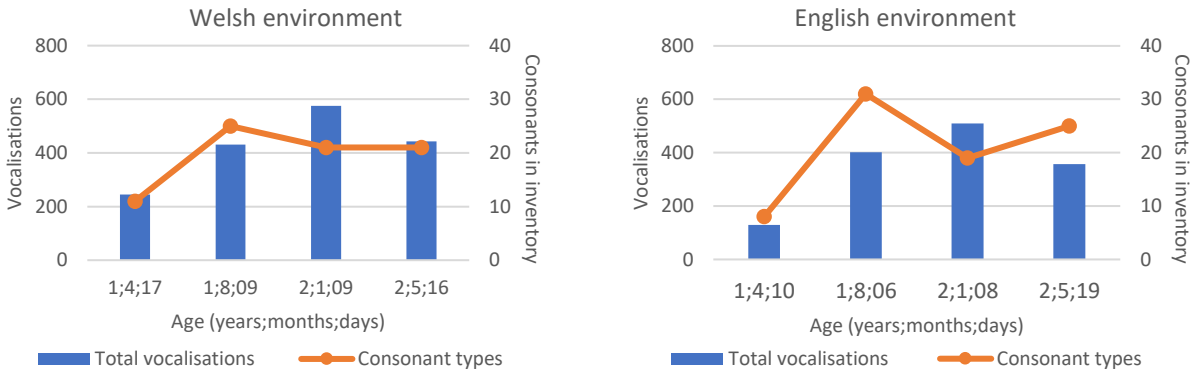


Figure 6.8 Number of vocalisations produced alongside number of consonants present in inventory for each session, Ben, Welsh and English environments

6.5.2 Size of inventory in words

Alongside consideration of the range of consonants produced by each child across all of the vocalisations they produced in each session, it is necessary to also consider which of these consonants are being utilised in the production of words. Previous studies suggest that children do not use all of the consonants available to them as they make their initial attempts to produce words (McCune and Vihman, 2001). This was shown for the TD group in this study as for their final analysed session, where they were deemed to have reached the 25-word-point, the size of their inventories amassed from all vocalisations ranged from 35 to 45 consonants whilst their inventories in words contained between 17 and 29 consonants. Figure 6.9. depicts the inventories derived from the word productions of all six participants. It is clear that once again Ben's speech production is notably different from the other five children. There is a steady rise in the number of different consonants produced in words across the data analysis period and the size of his inventory is very similar across the two language environments. There are greater numbers of consonants present in the inventories compiled from the other children's data by the end of the data collection period and, again, examination of the data reveals Ben's protracted development in terms of the variety of consonants produced in words over time.

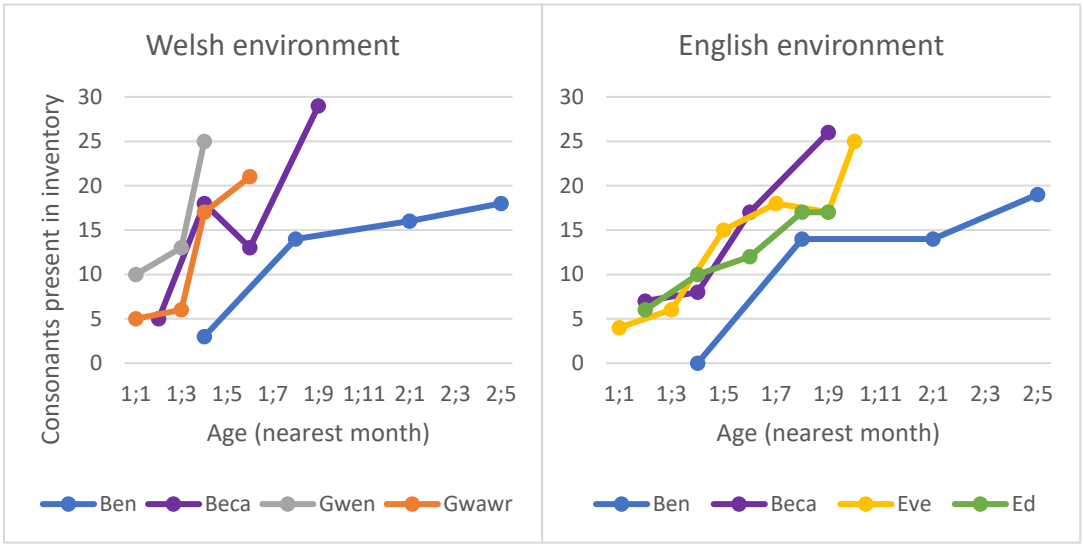


Figure 6.9 Size of consonant inventory at each data point, analysis of words only: Welsh and English environments

6.5.3 Inventory complexity in words

As well as examining the number of consonants produced in words, the nature of these consonants was investigated in the same way as was done for the TD group in section 4.5.3. It was expected the phonetic inventories would increase in complexity as word production progressed (Fabiano-Smith and Barlow, 2010; Montanari *et al.*, 2014; Dinnsen *et al.*, 1990). Inventory complexity was once again evaluated in terms of the number of manner classes contained (see Table 6.3). Inspection of Table 6.3 revealed that Ben's consonant production in words did include consonants from a range of manner categories, namely plosives, nasals, fricatives and approximants. Interestingly, during the earlier part of the single-word period, as shown by his session at 1;4;17, only three consonants were produced and two of them were fricatives.

Welsh environment					
Age	No. of word types	Consonants produced in words			
		Plosives	Nasals	Fricatives	Approximants
1;4;17	3	ʔ		ç h	
1;8;09	16	p b g q ʔ	m n ɲ ŋ	ɸ β h	j w
2;1;09	22	p b d ɟ ʔ	m n ɲ ŋ	ɸ β v x h	ʊ j
2;5;16	26	p b d ɟ g ʔ	m n ɲ ŋ	ɸ v ð x h	j w
English environment					
Age	No. of word types	Consonants produced in words			
		Plosives	Nasals	Fricatives	Approximants
1;8;06	12	b d ɟ ʔ	m n ɲ	ɸ β ç h	j w
2;1;08	16	p b d ɟ ʔ	m n	ɸ β v x h	ʊ j
2;5;16	20	b t d c ɟ k g ʔ	m n ɲ ŋ	ɸ f v x h	j w

Table 6.3 Consonant inventories derived from words, Ben: Welsh and English environments

The data collected from the TD group (section 4.5.3) revealed the gradual increase that had been described in the literature. Ben's inventories contained four manner classes from 1;8 onwards so a gradual increase in complexity was not seen. A noticeable difference between

Ben's inventories and those compiled for the other children is that his never contained five manner classes whilst all of the others' did. This is even more notable considering that Ben was far older than the members of the TD group by the end of the data collection period.

Taken together, the analyses that were related to the rate of consonant development provide considerable evidence for the notion that Ben's consonant production was different to that of the other children. There were fewer consonant types produced, both in all vocalisations and in words. Furthermore, his inventories were seen to be less complex as they contained fewer manner categories.

With regards to the nature of the consonants produced, there were some similarities seen with the TD group in terms of the overall prevalence of manner categories. However, analysis of Ben's data revealed changes over time across the single-word period that were not apparent when these proportions were scrutinised in the TD group. For place of articulation, there was a difference in overall proportions and across the developmental trajectory, which was particularly apparent for labial and post-velar consonants. Analysis of preferred sounds provided further evidence of the difference between Ben and those belonging to the TD group, with all of Ben's sessions containing one or more consonants produced at high frequencies.

For the next three sections of the chapter (6.6, 6.7 and 6.8), the focus will be on the structure of words. This will include an investigation of the target words attempted by Ben and the production attempts recorded.

6.6 A closer look at the vocalisations produced

6.6.1 Proportion of vocalisations identified as words

Within the majority of the sessions recorded, a proportion of the vocalisations produced were classified as words (see section 3.6.2 for an explanation of the word identification procedure). These were the vocalisations that were deemed to have been produced with the intent to convey meaning. Evidence was presented in the previous sections for Ben's speech development being different to those belonging to the TD group with regards to the segmental make-up of his vocalisations. But what about the function of the vocalisations he

produced? As he vocalised during the play activities observed, were these vocalisations produced with intent to convey meaning? With the intent of investigating to what extent the vocalisations Ben produced had meaning attached to them, the occurrence of words as a proportion of the total vocalisations produced was calculated (see Figure 6.10). Inspection of this figure revealed that the proportion of words within the total vocalisations produced was similar for all six of the children. In fact, Ben produced the highest proportion of words in both language environments.

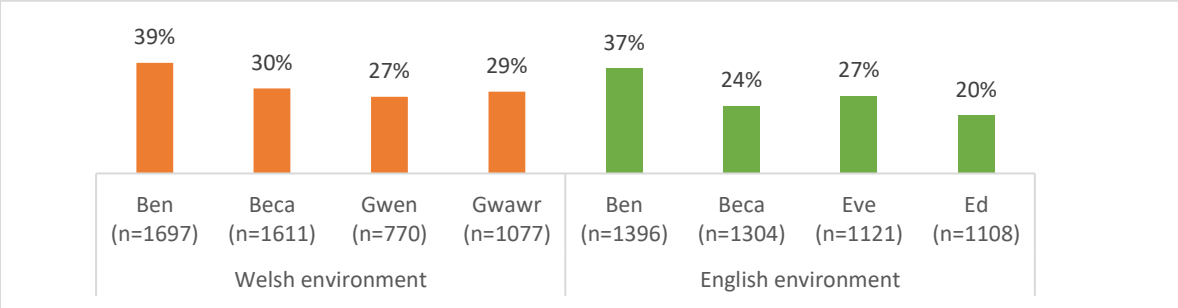


Figure 6.10 Proportion of vocalisations identified as words across all sessions. Total number of vocalisations produced depicted as n-value

Welsh environment						
Word-stage category		up to 7	8 to 15	16 to 24		25+
Ben		*1;4;17* 5%		*1;8;09* 23%	*2;1;09* 54%	*2;5;16* 52%
TD group	Beca	17%		16%		47%
	Gwen		8%	29%		34%
	Gwawr	18%	17%	29%		36%
English environment						
Word-stage category		up to 7	8 to 15	16 to 24		25+
Ben			*1;8;06* 29%	*2;1;08* 48%	*2;5;19* 42%	
TD group	Beca	17%	12%	15%		35%
	Eve	5%	19%	31%		50%
	Ed	16%	14%	18%		26%

Table 6.4 Proportion of all vocalisations identified as words with separate sessions depicted according to word-stage category, Welsh and English environments. (Ben's age at each session also noted in italics)

In order to investigate this further, proportions were calculated separately for each of Ben's sessions and then compared to the other children in accordance with word-stage categories (see Table 6.4). Inspection of this table revealed that there was an overall increase in the proportion of vocalisations produced that were categorized as words, with Ben's final session in the Welsh environment showing a particularly high proportion of words.

6.6.2 Type-token ratio for words

The analyses presented above show that Ben's sessions contained similar, if not more, word attempts than the participants belonging to the TD group. However, as demonstrated in section 6.2, the same could not be said for the number of word types he produced. In order to examine this further, the relationship between the number of words attempted and the number of word types recorded was investigated and compared to the other participants (see appendix D2 for the values used in the calculation and Table 6.5 for the ratios compiled). Examination of Table 6.5 revealed that for both language environments, Ben's type-token ratio was the lowest of all the children. Although Ben was producing a similar proportion of words, his productions contained fewer word types. This meant that the same target word was being repeated often, leading to output that was repetitive and lacking in variety.

Welsh environment		English environment	
Ben	0.09	Ben	0.13
Beca	0.19	Beca	0.20
Gwawr	0.25	Eve	0.30
Gwen	0.25	Ed	0.30

Table 6.5 Ratio of target word tokens as compared to types, all participants: Welsh and English environments

6.6.3 Target word types

The nature of Ben's word productions was first investigated through close examination of the target words he had attempted. Each word type attempted was coded on the basis of its word shape and the prevalence of each shape was calculated across all sessions captured in each language environment. The word shapes attempted are depicted in Figure 6.11, with both the number of types and the percentage occurrence for each word shape included. Percentages were calculated using the total number of word types recorded for each language. Where there was repetition of the same word across sessions, only one occurrence was included.

Inspection of this figure revealed that Ben's target words represented 10 different word shapes. This demonstrates a similar range of shapes to the TD group, where the inventory sizes ranged from 9 (Gwawr) to 13 (Eve).

There were also similarities in the shapes of the target words that Ben attempted as compared to the TD group. Firstly, the target word shapes most frequently produced were the same with CV, CVC and CV|CV being the most prevalent across both language environments. Secondly, a cross-linguistic difference that had been identified through analysis of the TD group data was also apparent in Ben's data. Namely, the proportions of CV and CVC words in the English environment were more similar than those seen in the Welsh environment, where CV words were targeted at higher proportions.

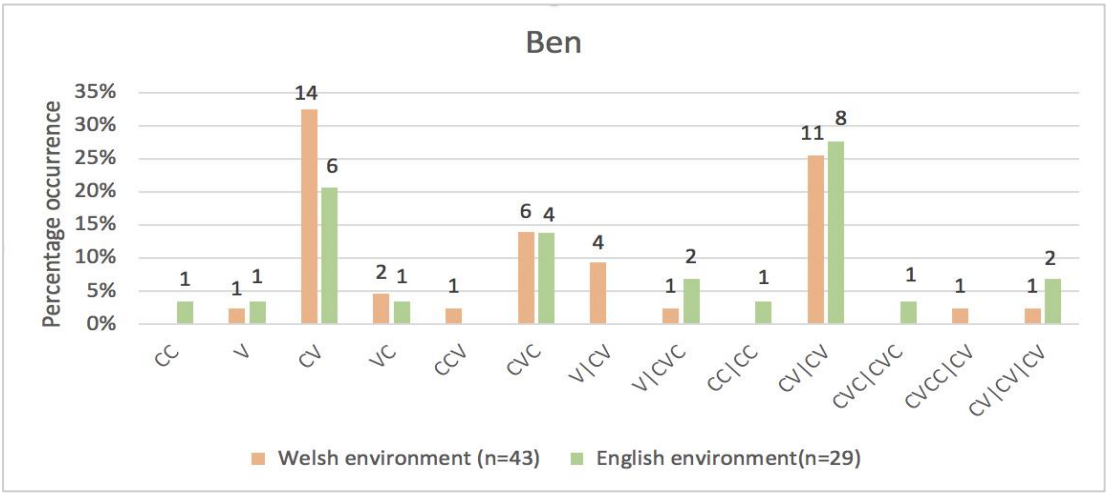


Figure 6.11 Word shape inventory, target word types; Ben, Welsh and English environments

Following investigation of the structure of the target words attempted, Ben's word production attempts were examined. In accordance with the analyses conducted in relation to the TD participants in Chapter 5, there was a specific focus on three structural properties: syllable number, presence of an onset and presence of a coda. The next three sections explore these properties in turn. Within each section, the investigation will start with an examination of the degree to which the attempts made matched the target in relation to the structural property being discussed. Then, the outcomes of cross-linguistic analyses that were conducted to investigate percentage occurrences relating to each structural property will be reported. Finally, the word attempts will be examined closely through application of the templatic approach.

6.7 Syllable number

Despite the limited variation in the syllable structure of the target words attempted by Ben, he did attempt to produce both monosyllabic and disyllabic words. The following sub-sections will explore Ben's word production attempts in terms of syllable number.

6.7.1 Degree of match to target

All of the word production attempts produced within the 30-minute sessions were coded in terms of syllable shape and compared to their targets in relation to the number of syllables they contained. From this, the occurrence of attempts that matched their targets on the basis of syllable number was calculated and depicted alongside the number of attempts that belonged to that category.

WELSH ENVIRONMENT									
Ben					Word-stage category	TD group comparison			
Age	Monosyllabic target		Disyllabic target			Monosyllabic. target		Disyllabic. target	
	n	Match to target	n	Match to target		n	Match to target	n	Match to target
1;4;17	1	100%	0	0%	up to 7	12	75%	30	77%
1;8;09	54	57%	30	83%	16 to 24	98	78%	70	77%
2;1;09	79	81%	39	79%					
2;5;16	150	91%	24	79%	25+	147	63%	157	77%
ENGLISH ENVIRONMENT									
Ben					Word-stage category	TD group comparison			
Age	Monosyllabic target		Disyllabic target			Monosyllabic target		Disyllabic target	
	n	Match to target	n	Match to target		n	Match to target	n	Match to target
1;4;10	0	0%	0	0%					
1;8;06	46	63%	32	78%	8 to 15	40	77%	18	90%
2;1;08	42	83%	20	90%	16 to 24	52	63%	36	77%
2;5;19	116	91%	10	100%					

Table 6.6 Degree of match to target with regards to syllable number; Ben and TD group comparison: Welsh and English environments

Table 6.6 contains Ben's data alongside the amassed values from the TD group, as related to the relevant word-stage categories. Inspection of this table revealed that Ben's only word attempt during his first session in the Welsh environment was monosyllabic as was the target, leading to a 100% match. When Ben was 1;8;06-09, his degree of match was lower than that of the TD group. These two sessions relate to the '8 to 15' category in the English environment and the '16 to 24' in the Welsh environment. By the second session in the Welsh environment that fell into the '16 to 24' category, Ben was 2;1;09, and his degree of match to target was more in line with the TD group. In the English environment, Ben's degree of match to target in the third and fourth sessions was higher than that seen in the TD group.

6.7.2 Word production attempts in different language environments

To further examine Ben's word production behaviour as he attempted to produce the various targets, his attempts were categorised according to the number of syllables they contained. The outcome of this analysis is depicted in Figure 6.12 below. Inspection of this figure revealed that although the majority of his attempts to produce monosyllabic targets were monosyllables, there were also examples of di- and multisyllabic attempts. Similarly, when he attempted disyllabic targets, he mainly produced disyllables, but also produced monosyllables and multisyllables. These patterns are similar across both language environments. They echo what was found for the TD group in the between-child and within-child comparisons (sections 5.3.2 and 5.3.3).

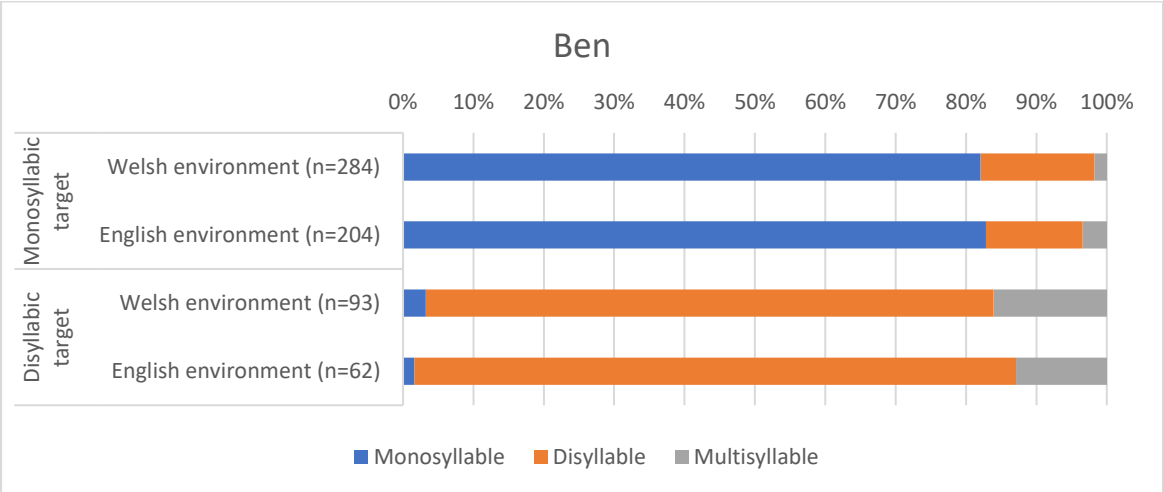


Figure 6.12 Word production attempts of differing lengths according to the number of syllables within the target word: Within-child cross-linguistic comparison

6.7.3 Individual samples: Application of the templatic approach

In the same way as for the TD group in Chapter 5, the patterns of syllable addition and omission were further explored by examination of individual word attempts. The templatic approach (Vihman and Croft, 2007) was once again applied and selected and adapted forms were identified through grouping together of word production attempts conforming to the same word shape and identifying patterns (see section 5.3.4 for the patterns identified for Beca, Gwen and Eve). The analysis was separated according to the shape of the selected forms and the resulting adapted forms. Word production attempts with a CV word shape are depicted in Table 6.7. There were several selected forms (i.e. those which conformed to the CV template and were a relatively close match to their target) and a small number of adapted forms showing how, across both language environments, disyllabic words and phrases were adapted to a monosyllabic CV template through syllable omission.

<CV>		
Welsh environment		
	Selected forms	Adapted forms
		Syllable omission CVCV(C) → CV
1;4;17	'da' /da/*(tah)* [dă]	
1;8;09	'da' /da/*(tah)* [tạ] 'na' /na/*(no)* [ɲa](3) [naː]	'parrot' [pʰa]
2;1;09	'na' /na/*(no)* [na](41)	'a-ha'/aha/*(ah-ha)* [ha](2)
English environment		
	Selected forms	Adapted forms
		Syllable omission CVCCVC → CV
1;8;06	'na' /na/*(no)* [na](3) [ɲa](7)	'who's that' [hʊa]

Table 6.7 Word production attempts adapted to CV through syllable omission, Ben: Welsh and English environments

Word production attempts with a CVCV shape are depicted in Table 6.8. There was a range of selected forms identified across both language environments. Ben exhibited similar patterns to Beca, Gwen and Eve with words being adapted to the <CVCV> template through repetition, or reduplication (Grunwell, 1987). Examples from the Welsh environment

<CVCV>		
Welsh environment		
	Selected forms	Adapted forms
		Syllable addition CV(C) → CVCV
1;8;09	'bi-bo' /bibo/*(pee-po)* [bəbaː] [babaː] 'o-ow' /ʔəʔəʊ/*(uh-oh)* [ʔə̆ʔəʊ]	'na' /na/*(no)* [hɔ̨ɲa] 'da' /da/*(tah)* [qa.ga]
2;1;09	'bye bye' [bə.ba] [bɛbaɪ](2) [babaɪ]	'back' [bə.bə] 'dad' [gaɪpɛ̨] 'na' /na/*(no)* [na.ɲaː] [nama] 'ow' /ʔəʊ/*(oh)* [ʔaʊʊ̆]
2;5;19	'sana' /sana/*(socks)* [nana] 'oh na' /ʔəʊna/*(oh no)* [ʔəʊŋaː] [ʔəʊnaː]	'na' /na/*(no)* [ʔa·maː] [naha](2) 'ow' /ʔəʊ/*(oh)* [ʔaʊʔaʊ](2) [ʔəʊʔaʊ]
English environment		
	Selected forms	Adapted forms
		Syllable addition CV(C) → CVCV
1;8;06	'daddy' [dadi] [d̪eḍi] 'haia' [haɪja·] [haɪjɛ]	'na' /na/*(no)* [ɲaʔa] [dɜːjə̨] [haɪɲa] [haɲa·]
2;1;08	'bye bye' [baɪba·] [babaɪ](2) 'hiya' [haɪja·]	'na' /na/*(no)* [hanaː]
2;5;19	'hiya' [haɪja]	'lawr' /laʊr/*(down)* [haʊhaʊ] 'bag' [hə̨baː] 'na' /na/*(no)* [ʔəŋaː] 'wow' [hɛwɛʊ]

	Adapted forms
	Syllable omission CVVCVC → CVCV CVCVCV → CVCV
1;8;06	'who is it' [huɪjɛ]
2;1;08	'oh dear' [həhiɛ] [hɛɪjɛ] [hɛjɛːː]
2;5;19	

Table 6.8 Word production attempts adapted to CVCV through syllable addition and omission, Ben: Welsh and English environments

included production of ‘back’ at 2;1;09 as [bə.bə] and in the English environment, at 2;1;08, he produced ‘na’ as [hanaː]. Many of the words listed as examples of the <CVCV> could also be attributed to the more specific template <hVCV> especially in the English environment. At 1;8;06, Ben produced ‘na’ as [haɪŋa] and [haŋa] at 1;8;06 and [hanaː] at 2;1;08. Then at 2;5;19, several different words were adapted to this template, ‘lawr’ was produced as [haʊhaʊ], ‘bag’ as [hə̰baː] and ‘waw’ as [hɛwɛʊ]. Adaption to the <CVCV> template also meant syllable omission in the English environment. Interestingly, all three examples of this also conformed to the more specific <hVCV> template.

Multisyllabic word production attempts are depicted in Table 6.9. The table shows that target words with multiple syllables were very few in number. However, he produced many multisyllabic words through the addition of syllables to mono- and di-syllabic targets. Many of the examples listed in the table below provide further evidence of reduplication as elements of the syllables produced are repeated, multiple times on some occasions

.

<CV(C)CVC(C)V>		
Welsh environment		
	Selected forms	Adapted forms
		Syllable addition
1;8;09		‘ta ta’/tata/*(bye bye)* [bababaˑ] [wəfbabaː] ‘a-ha’ /aha/*(ah-ha)* [ʔahaːa]
2;1;09		‘haia’ /haɪja/*(hiya)* [ʔɛɪja.jaː] ‘a-ha’ /aha/*(ah-ha)* [haha:hă](2) ‘bye bye’ [bɛβə.ba] ‘back’ [bə.βə.ba] ‘be-beis’ /bɛbeɪs/*(a colloquial word for sleep)* [bə.bə.bβəː]
<CVCVCV(CV)>		
English environment		
	Selected forms	Adapted forms
		Syllable addition
1;8;06		‘ta ta’ /tata/*(bye bye)* [ʔaʊbabaˑ] ‘daddy’ [da̪ʊda̪ʊdi]

		[diḏeɪdeɪdɛ] [ɟɛɟidɛḏi] 'no' [neʊɲaʔə̆ʔə̆]
2;1;08	'oh dear' [həʊijə]	'ta ta' [babaʊ.baba] 'no' [nɛʊəʊʊʲəʊʊʲəʊ] [nəʊʊəʊʊəʊʊə·ʊ]
2;5;19	'aw aw aw' [ʔaːʔaʊʔaːʊ]	'lawr' /laʊr/*(down)* [ʔahahaːʊ]

Table 6.9 Multisyllabic adaptations through syllable addition, Ben: Welsh and English environments

6.8 Onset patterns

6.8.1 Degree of match to target

The word production attempts were also coded and compared to their targets on the basis of the presence or absence of an onset. Ben's degree of match to target for target words with and without onsets is depicted in Table 6.10, with values from the TD group included for comparison. Inspection of this table revealed that where the target words contained onsets, there was a very high likelihood that Ben's production types did too. This was also true for the TD group. Where words did not have an onset, the percentages revealed that adherence to the target syllable shapes was low for Ben and for the TD group.

WELSH ENVIRONMENT									
Ben					Word-stage category	TD group comparison			
Age	Target with onset		Target without onset			Target with onset		Target without onset	
	n	Match to target	n	Match to target		n	Match to target	n	Match to target
1;4;17	1	100%	0		up to 7	38	81%	1	0%
1;8;09	80	99%	2	0%	16 to 24	176	97%	7	27%
2;1;09	114	96%	1	0%					
2;5;16	163	98%	7	14%	25+	399	98%	4	10%

ENGLISH ENVIRONMENT									
Ben					Word-stage category	TD group comparison			
Age	Target with onset		Target without onset			Target with onset		Target without onset	
	n	Match to target	n	Match to target		n	Match to target	n	Match to target
1;4;10									
1;8;06	69	100%	1	0%	8 to 15	60	100%	3	10%
2;1;08	52	100%	9	11%	16 to 24	118	100%	0	0%
2;5;19	123	99%	2	0%					

Table 6.10 Degree of match to target with regards to presence or absence of an onset; Ben and TD group comparison: Welsh and English environments

6.8.2 Word production attempts in different language environments

The proportion of Ben's word production attempts that contained and did not contain onsets were calculated, and are depicted for each target word type in Figure 6.13. Inspection of this figure revealed that regardless of the presence or absence of an onset within the target word, the majority of Ben's word production attempts contained an onset. The proportions were similar across both languages. Comparison to the same analyses conducted for the TD group revealed that Ben's attempts to produce target words without onsets were more likely to contain onsets than those of the TD group (see section 5.4.2). It is worth noting that attempts to produce words that that did not contain onsets were rare.

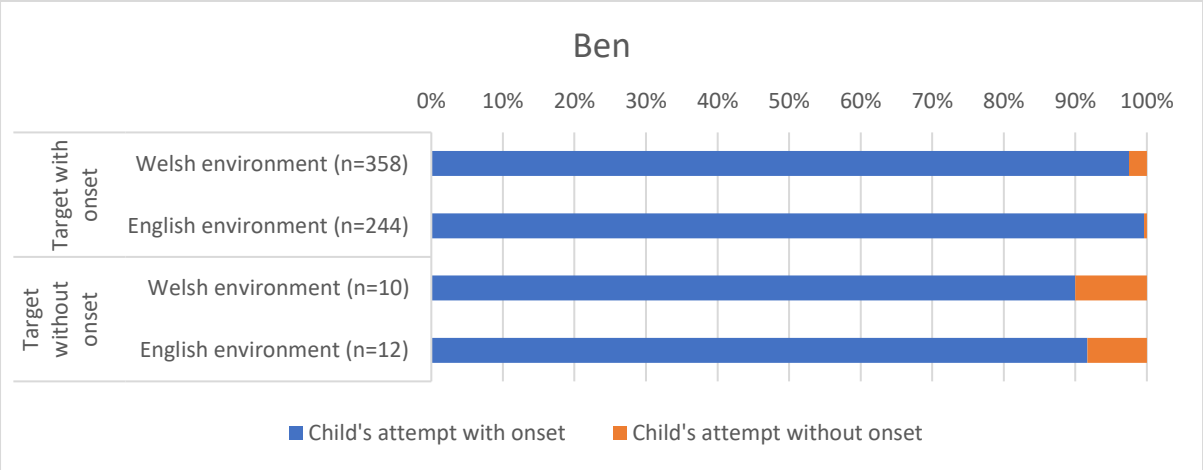


Figure 6.13 Word production attempts with and without onsets according to structure of target words: Within-child cross-linguistic comparison

6.8.3 Individual samples: application of the templatic approach

Once again, individual word attempts were examined in order to explore the patterns of adaptation that had occurred in relation to onsets. In the same way as before, lists of word production attempts belonging to the same word shape were examined. Words belonging to the <CV> template are depicted in Table 6.11. .

<CV>		
Welsh environment		
	Selected forms	Adapted forms
		Onset addition V(C) → CV(C) CVCCVC
1;4;17	'da' /da/*(tah)* [dă]	
1;8;09	'na' /na/*(no)* [ŋaː]	'o' /ɔː/*(oh)* [haa] 'ah' /a/*(ah)* [haː]
2;1;09	'na' /na/*(no)* [na] 'wiː' /wi/*(wee).* [hiː]	'ach' /ax/*(yuk)* [haxhaːx]
2;5;16	'na' /na/*(no)* [na·]	'o' /ɔː/ */(oh)* [ʔɔː] [ʔɔ] [ʔəm] 'ym' /ʌm/*(erm)* [ʔɜ·] 'ach'/ax/*(yuk)* [haːx](2)
English environment		
1;8;06	'no' [ɲa] [nɔ]	'all gone' [bəbu·]
2;1;08	'na' /na/*(no)* [na]	'erm' [həm] [ha·m] [hɛːm](2) [hɛmhɛm]
2;5;19	'oh' [ʔəʊ] 'pooh' [biː]	'all gone' [ʔaɪgɑc]

Table 6.11 Word production attempts adapted to CV through addition of an onset; Ben: Welsh and English environments

Here, the addition of an onset is seen to consist of [h] or [ʔ]. Many of these productions could be attributed to the <h__> template, with a variety of word shapes following the same

pattern with an initial glottal fricative. This relates to what was found when identifying templatic productions in relation to the addition or omission of syllables, where the <h__> template was also prevalent. Another pattern of note within Table 6.11 is reduplication. Despite the focus here not being syllable addition, instances of onset addition are also demonstrating the repetition of a syllable, for example, where he says [haxhaːx] for 'ach' /ax/ *(yuk)* in the Welsh environment at 2;1;09 and [hɛmhɛm] for 'erm' in the English environment at 2;1;08.

Words belonging to the <VCV> template are depicted in Table 6.12. Here, there was only one selected form which was identified when Ben was 2;5;16 and in the Welsh environment. A small number of adapted forms demonstrating onset omission occurred across both language environments.

<V> <VCV>		
Welsh environment		
	Selected forms	Adapted forms
		Onset omission CV(CV) → V VCV
1;4;17		'a-ha' /ʔaha/*(ah-ha)* [ija] 'wi'/wiː/*(wee)* [iːːː]
2;1;09		'haia'/haɪja/*(hiya)* [aɪ̯ja]
2;5;16	'o wel' /ɔ wɛl/*(oh well)* [ɔwɛʊ]	
English environment		
	Selected forms	Adapted forms
		Onset omission CVCV → VCV
2;5;19		'haia'/haɪja/*(hiya)* [aɪja]

Table 6.12 Word production attempts adapted through onset omission; Ben: Welsh and English environments

There were also instances where target words containing an onset were produced without an onset that did not appear to be due to onset omission; these are depicted in Table 6.13. Here, vowels were being added to the beginning of words. For example, as he attempted 'na'/na/ *(no)* in the Welsh environment at 2;1;09, he produced [ʊɪŋaŋa] and [eɪŋa]. In these attempts, the target word was present but produced alongside additional syllables, the first of which

was without an onset. Interestingly, some of these attempts also demonstrated reduplication, which seemed to be a common behaviour exhibited by Ben across target words featuring a range of structural properties.

<VCV(CV)(CV)>		
Welsh environment		
	Selected forms	Adapted forms
		CV(C)→ VCV(CV)(CV)
2;1;09		'na'/na/*(no)* [ʊɪŋaŋa] [eɪŋa]
English environment		
2;5;19		'lawr'/laʊr/*(down)* [ahaha:ʊ] [ahamɪ:v.aʊ]

Table 6.13 Word production attempts featuring addition of an initial vowel; Ben: Welsh and English environments

6.9 Coda patterns

6.9.1 Degree of match to target

Presence or absence of a coda was the final structural property by which Ben's word production attempts were compared to the targets. In the same way as previously, the percentage match to target is depicted for all of Ben's sessions, with a TD group value depicted and related to the word-stage category for comparison (see Table 6.14). Inspection of this table revealed that for targets that did not contain a coda, there was a high degree of match to the target. For targets with a coda, there was a lower degree of match, but not as low as that seen for targets without an onset (section 6.8.1). In the Welsh environment, the TD group's percentage match to target was lower than Ben's for the '16 to 24' word-stage category but then far lower for the final word-stage category '25+'. In the English environment, it was higher than the TD group's for the '16 to 24' category, where Ben was the same age as the final word-stage category in the Welsh environment.

WELSH ENVIRONMENT									
Ben					Word-stage category	TD group comparison			
Age	Target without coda		Target with coda			Target without coda		Target with coda	
	n	Match to target	n	Match to target		n	Match to target	n	Match to target
1;4;17	1	100%	0	0%	up to 7	45	90%	0	
1;8;09	82	95%	0	0%	16 to 24	129	91%	36	62%
2;1;09	109	99%	6	33%					
2;5;16	60	95%	110	90%	25+	276	85%	52	45%
ENGLISH ENVIRONMENT									
Ben					Word-stage category	TD group comparison			
Age	Target without coda		Target with coda			Target without coda		Target with coda	
	n	Match to target	n	Match to target		n	Match to target	n	Match to target
1;4;10	0	0%	0	0%					
1;8;06	62	100%	8	63%	8 to 15	36	95%	37	74%
2;1;08	41	93%	20	95%	16 to 24	71	91%	24	63%
2;5;19	55	96%	70	86%					

Table 6.14 Degree of match to target with regards to presence or absence of a coda; Ben and TD group comparison: Welsh and English environments

6.9.2 Word production attempts in different language environments

Ben's word production attempts in each language environment were further investigated in relation to the presence or absence of a coda through calculation of percentage occurrence of each type of attempt (see Figure 6.14). Inspection of this figure revealed a great deal of cross-linguistic similarity. There was general adherence to the structural properties of the target word, with a slightly higher proportion of target words without codas being produced without a coda than those with a coda being produced as such. When compared to the participants belonging to the TD group (section 5.5.2), Ben produced codas in a higher proportion of attempts at target words containing codas than the TD group.

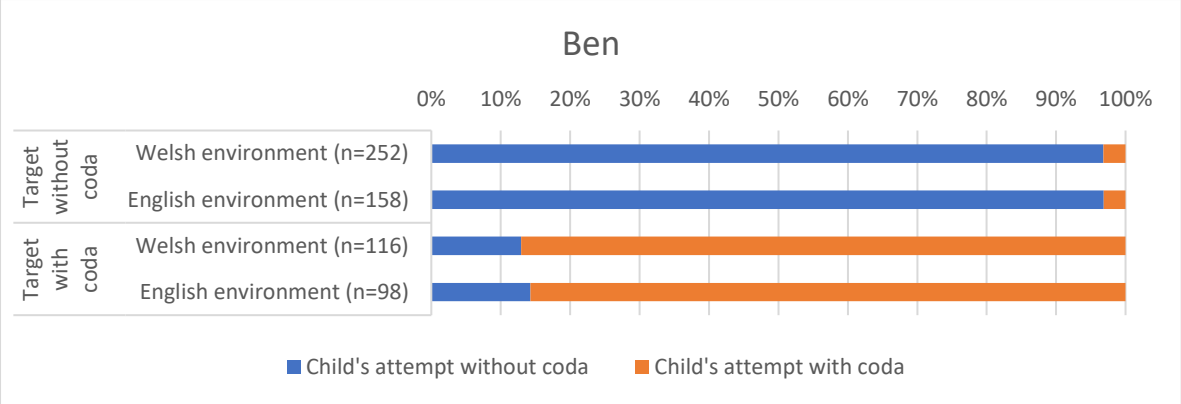


Figure 6.14 Word production attempts with and without codas according to structure of target words: Within-child cross-linguistic comparison

6.9.3 Individual samples: Application of the templatic approach

For a final time, the identification of word production attempts was undertaken, with lists of words belonging to the same syllable shape being examined. The focus in this section was patterns involving addition or omission of a coda. The coda is omitted during adaptation to the CV (Table 6.15) and to CVCV (Table 6.16).

<CV>				
Welsh environment				
	Selected forms		Adapted forms	
			Coda omission CVC → CV	
1;4;17	'da'/da/*(tah)*	[dă]		
1;8;09	'da' /da/*(tah)* 'na' /na/*(no)*	[tạ] [ɲa](3) [ŋa] [ɲːa]		
2;1;09	'na' /na/*(no)*	[na](41)	'back'	[b̪a]
2;5;19	'na' /na/*(no)*	[na](16)	'mam' /mam/*(mum)* 'lawr' /laʊr/*(down)*	[maʊ] [maʊ]
English environment				
	Selected forms		Adapted forms	
			Coda omission (CVC)CVC → C(C)V	
1;8;06	'na' /na/*(no)*	[na](3)	'who's that'	[hʊa]
2;5;19	'da' 'na' 'ow'	[da](2) [na](15) [ʔəʊ](4)	'lawr' /laʊr/*(down)* 'dad'	[haːʊ](2) [gaː]

Table 6.15 Word production attempts adapted to CV through omission of a coda, Ben: Welsh and English environments

This pattern was also identified for Beca, Gwen and Eve and described in section 5.5.4. It has been described widely throughout the literature as *final consonant deletion* (Grunwell, 1987). The presence of the <h___> template can be seen here also with 'who's that' produced as [hʊa] and lawr' /laʊr/*(down)* as [haːʊ], both in the English environment, belonging to the <hV> template. Also, 'who is it' produced as [huɪjɛ] belonging to the <hVCV> template.

<CVCV>		
Welsh environment		
	Selected forms	Adapted forms
		Coda omission CVCVC → CVCV
1;8;09	'bi-bo' /bibo/*(pee-po)* [bəba:] [baba:] 'o-ow' /ʔəʔəʊ/*(uh-oh)* [ʔəʔəʊ] 'ta-ta' /tata/*(bye bye)* [baba](12)	
2;1;09	'bye bye [bɛbaɪ](2)	'be-beis' /bɛbeɪs/*(a colloquial word for sleep)* [bə.bə]
2;5;19	'sana' [nana]	'bib bib' /bibib/ *(beep beep)* [pipi]
English environment		
	Selected forms	Adapted forms
		Coda omission (C)VCCVC → CVCV CVVCVC → CVCV
1;8;06	'daddy' [dadi] 'haia' [haɪja·]	'all gone' [bəbu·] 'who is it' [huɪjɛ]

Table 6.16 Word production attempts adapted to CVCV through omission of a coda, Ben: Welsh and English environments

As well as word production attempts demonstrating the tendency for coda omission, there were also instances where a coda was added, resulting in a CVC word shape (Table 6.17). Selected forms belonging to the CVC word shape were identified in both language environments, as well as the adaptation of CV and V target words. Interestingly, the codas added were often fricatives, with the addition of the bilabial fricative when 'wow' was produced as [ha·ʊɸ] and [ha:ɸ] at 1;8;09 in the Welsh environment and in the English environment when 'oh' was produced as [ɛʊɸ] and [əʊɸ] at 1;8;06 and [ʔəʊɸ] at 2;5;19. As was described in relation to Beca's productions in section 5.5.4, Ben's productions could be attributed to the template $<CVC_F>$ or $<VC_F>$.

<CVC>		
Welsh environment		
	Selected forms	Adapted forms
		Coda addition CV → CVC
1;8;09		'wow' [ha·ʊɸ] [haːɸ] 'ow' /ʔəʊ/*(oh)* [ʔəʊŋ] 'da' /da/*(tah)* [ɢaʁ]
2;1;09	'mam' /mam/*(mum)* [mɛm]	
2;5;19	'bib' /bib/*(beep)* [biːb] 'mam'/mam/*(mum)* [mam](82)	'blue' [bɪːv] 'na' /na/*(no)* [nap] 'ow' /ʔəʊ/*(oh)* [ʔɛʊx]
English environment		
	Selected forms	Adapted forms
		Coda addition (C)V → (C)VC
1;8;06		'oh' [ɛʊɸ] [əʊɸ]
2;1;08	'dad' [ɟaːd]	'oh' [ʔɛɪʊ]
2;5;19	'dad' [da·d](3) 'mam'/mam/*(mum)* [ma·m](3)	'oh' [ʔəʊɸ] [ʔəʊv]

Table 6.17 Word production attempts adapted to CVC through addition of a coda; Ben: Welsh and English environments

6.10 Intra-word variability

Whilst there was a degree of regularity identified in Ben's output, given his repetitive use of segments and syllable structures, there was also a great deal of variability when multiple occurrences of the same words were compared. In the same way as was done for the TD group in section 5.6, variability ratios were calculated for each session (Sosa and Stoel-

Gammon, 2006). As described in detail in section 3.6.4, words attempted three or more times were subject to variability analysis. For each of these words, the number of variant forms was divided with the total number of tokens for that word. These values were amassed for each session to give an overall variability ratio, thus allowing for the examination of changes in variability over time (see Figure 6.15). Inspection of Figure 6.15 revealed that there was an overall decrease over time in the intra-word variability recorded for Ben, especially in the Welsh environment. It could be seen that the degree of variability was fairly similar across both the language environments.

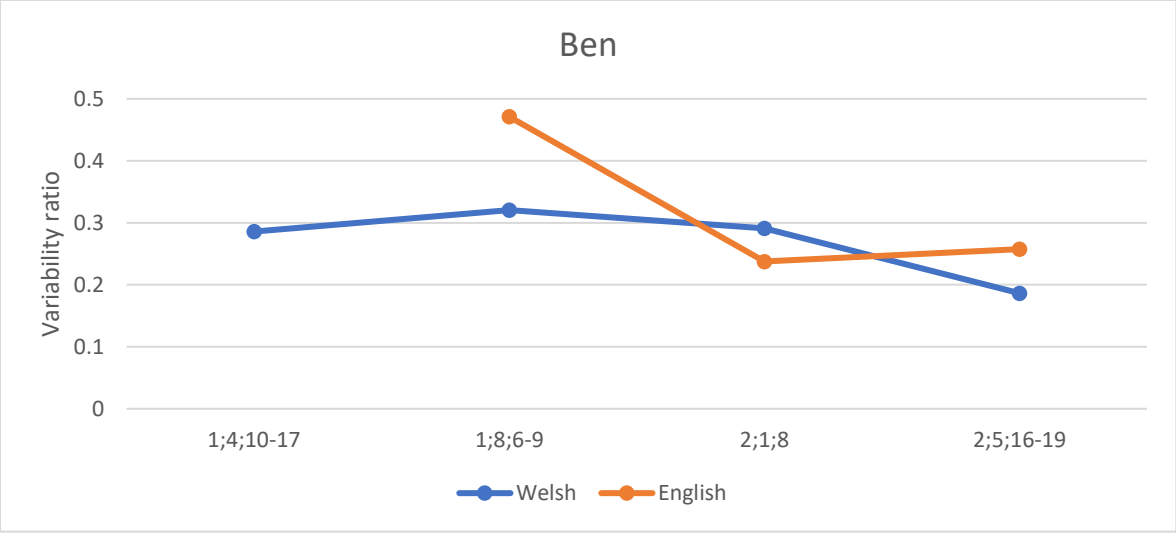


Figure 6.15 Overall variability ratios for each session; Ben: Welsh and English environments

In order to compare these values with those recorded for the participants belonging to the TD group, Ben's sessions were once again categorised according to word-stage and the ratios for the other 5 participants at each stage were depicted alongside (see Table 6.18). Inspection of Table 6.18 revealed that Ben's intra-word variability was low compared to the other participants.

Welsh environment						
Word-stage category		up to 7	8 to 15	16 to 24		25+
Ben		*1;4;17* 0.29		*1;8;09* 0.32	*2;1;09* 0.29	*2;5;16* 0.19
TD group	Beca	0.59		0.63		0.35
	Gwen		0.57	0.30		0.49
	Gwawr	0.36		0.47		0.61
English environment						
Word-stage category		up to 7	8 to 15	16 to 24		25+
Ben			*1;8;06* 0.47	*2;1;08* 0.24	*2;5;19* 0.26	
TD group	Beca	0.5	0.6	0.56		0.45
	Eve	0.6	0.6	0.6		0.42
	Ed	0.56	0.57	0.75		0.27

Table 6.18 Comparison of overall variability ratios with separate sessions depicted according to word-stage category, Welsh and English environments (Ben's age at each session also noted in italics)

6.11 Discussion

The aim of this chapter was to present the outcomes of the analyses conducted on Ben's data and to make comparisons with the other five participants in order to draw conclusions regarding typical and atypical development. Concerns that had been raised during the data collection period regarding his speech and language development lagging behind his peers' led to the decision to discuss Ben's data separately. By examining Ben's production of consonants and words, it was possible to identify several aspects where his abilities differed from those within the typically developing group. Previous studies featuring bilingual children with atypical speech development have featured older children with participants being recruited from clinical caseloads (Holm *et al.*, 1999; Holm and Dodd, 1999a; Ball, Müller and Munro, 2006; Hambly *et al.*, 2013). As Ben had taken part in the study before concerns had been raised regarding his speech and language development, this study offered

a unique opportunity to study the early productions of a child that did not follow the expected trajectory.

The growth of his lexicon was protracted; therefore the time period studied was far longer, with analysis of sessions taking place well beyond his second birthday. In the presence of individual variation, the five participants already discussed had followed the expected developmental trajectory in terms of their production of consonants and words. Comparison with Ben's data on the basis of age and word-stage revealed several key differences. However, this was not the case for all the parameters studied. In light of this finding, the speech production behaviours identified that demonstrated Ben's similarity to the other children will be discussed first, followed by a discussion of the main differences that suggest atypical speech development.

6.11.1 Similarities

Through detailed inspection of the data, several similarities were identified between Ben's speech production behaviour and that of the TD group in relation to the content and function of the vocalisations produced. Whilst the duration of Ben's single-word period was longer, both the number of vocalisations he produced and the proportion that could be identified as words was similar to the other participants. He became increasingly voluble as the sessions went by and produced a substantial proportion of his vocalisations with the intent of conveying meaning. The vocalisations he produced contained a similar proportion of consonant place and manner categories and these were in line with expectations drawn from previous studies featuring the speech development of young children (Locke, 1989). There was cross-linguistic similarity across his Welsh and English environments, which reflected the trends identified through between- and within-child comparisons undertaken in relation to participants belonging to the TD group.

Ben's lexical development was different from the other five children's and this is discussed further in the next section. However, there were some similarities in the nature of the development, albeit relating to a different timeframe. Firstly, Ben showed a similar decrease in intra-word variability, which, as with the TD group (section 5.6), does not align with the findings presented by Sosa and Stoel-Gammon (2006) where variability was seen to increase towards the end of the single-word period. Interestingly, the degree of variability

demonstrated by the ratios calculated was lower than for the TD group. This could be due to the fact that he attempted a smaller range of target word types and therefore there was less opportunity for variability.

Another similarity with the TD group that was related to word production was the tendency for the target words attempted to conform to the CV, CVC or CVCV word shapes. The cross-linguistic differences identified were also maintained, suggesting that target word selection was affected by the ambient language in the same way across typical and atypical developmental profiles. The word production attempts also followed a similar pattern. Where the analysis focused on the children's ability to adhere to the structural properties of the target words, similarities were found between Ben's abilities and those of the TD group. This revealed that, despite his lexical development being protracted, he was able to match his attempts with the target in terms of syllable numbers, onset patterns and coda patterns throughout the period examined.

Application of the templatic approach allowed for identification of both selected and adapted forms within Ben's data. The presence of adapted forms across both language environments suggests that the process of phonological systematisation had begun (Vihman and Croft, 2007; Velleman and Vihman, 2002). It was interesting to see that the specific patterns of syllable repetition and addition of a coda that had been identified in Beca's, Gwen's and Eve's samples were also present in Ben's data.

Although the bilingual societal context was common to all participants involved in this study, the dual-language home environment was only shared by Ben and Beca. There were similarities in the language practices adopted within their homes with both children being exposed to Welsh via their mothers and English via their fathers. As is common for many bilingual children, their skills did not develop evenly across their languages, with both children producing more word types and tokens in their Welsh sessions at each data point, as compared to English. This is likely to be related to differences in input patterns (section 2.4.2) with greater exposure to Welsh over time, leading to greater advancement of lexical abilities over time. This was especially true for Ben as his exposure to Welsh from age 1;3 onwards was greater than his exposure to English as he spent all of his weekdays with his mother who spoke to him in Welsh (see Appendix A1).

6.11.2 Differences

Despite various similarities that were identified between Ben and the TD group regarding consonant and word production, many differences were also found. It took longer for Ben to establish word production and the growth in the number of word types he produced in each session was far smaller than that seen for the other participants. At 1;9;9, Beca produced 59 and 57 word types in the Welsh and English environments, respectively. Ben produced 16 and 12 word types at 1;8;09 (Welsh environment) and 1;8;06 (English environment), and the maximum word types he produced across both subsequent sessions (2;1 and 2;5) was 26 types. Although Ben was producing vocalisations with the intent to convey meaning at a rate that was similar to the other participants, the range of different meanings being conveyed was limited. His output was very repetitive as a result and often consisted of expressing that he agreed or disagreed with suggestions offered by his mother or father.

Ben's vocalisations contained a preponderance of CV syllable shapes, often produced in long jargon strings e.g. at 2;5 he produced [məmhahabababa] and [pʰabawabahaɪjaʊababa] in the Welsh environment, [ʔahahabɔbɔbaː] and [həbibiĭhaɪhaɪhaɪ] in the English environment. The strings he produced contained various intonation patterns and were often successfully interpreted by his parents, due to their familiarity with his method of communication. However, to anyone not familiar he was extremely difficult to understand as the recognisable words only made up a small portion of the meaning he was trying to convey in amongst widespread jargon. Whilst jargon is present in the speech of typically developing children as well, a reduction in its use is seen as word production is established (Kern, Davies and Zink, 2009). Ben's limited number of word types along with continued use of jargon strings led to the conclusion that Ben's expressive language is not following the typical developmental trajectory.

Children with protracted lexical development in the absence of other cognitive or physical difficulties and receptive language abilities that are relatively intact can be described as *late talkers* (Williams and Elbert, 2003; Carson *et al.*, 2003; Stokes and Klee, 2009). These children are characterised as having a lexicon of fewer than 50 words at 22 months and a narrow consonant inventory (Williams and Elbert, 2003). Data were presented from when Ben was 20, 25 and 35 months (see Table 6.19). Recall that 25 different words produced in a

30-minute session is taken as an indicator of a lexicon of 50 words (DePaolis, Vihman and Kunnari, 2008; Vihman, 1993; Vihman and Velleman, 2000). It could be surmised that Ben had a lexicon of 50 words by his final recorded session in the Welsh environment, but that he did not reach this point in the English environment within the data collection period.

Differences with the TD group were also present in relation to the rate of consonant development as indicated by the growth of his phonetic inventory. Williams and Elbert (2003) analysed the phonetic and lexical development of five late talkers between the ages of 22 and 42 months. Their participants were separated into two groups, three of them were reported to have caught up with age-matched peers by 33-35 months, due to having similar phonetic inventories, syllable structures and accuracy scores, whilst two did not. In terms of consonant development, there was substantial variation within the size of their inventories over the data collection period. At 25 months, Ben's inventories in words contained 16 and 14 consonants in Welsh and English, respectively in comparison to 8 and 17 consonants seen for the two participants belonging to the younger group. At 35 months, Ben's inventories contained 18 and 19 consonants whereas the participants of the older group in Williams and Elbert (2003) produced 21, 14 and 8 consonants in words. Both participants in the younger group and the one with an inventory size of 21 at 35 months were deemed to have caught up with their peers while the other two were described as not having done so. It seems therefore that Ben's profile has greater similarity with the three children without persistent speech and language difficulties.

	Welsh environment				English environment			
Age (years;months;days)	1;4;17	1;8;09	2;1;09	2;5;16	1;4;10	1;8;06	2;1;08	2;5;19
Age (completed months)	16	20	25	35	16	20	25	35
Number of word types	3	16	22	26	0	12	16	20
Number of word tokens	12	98	313	232		116	246	151
Size of consonant inventory in words	3	14	16	18		14	14	19

Table 6.19 The rate of Ben's phonetic and lexical development across both languages

Inventory complexity was raised as a point of difference between Ben and members of the TD group, with four being the maximum number of manner categories featuring in his inventories whilst the five other children produced consonants belonging to five different categories. Studies investigating the complexity of phonetic inventories have generally featured older children, with the monolingual English group in Fabiano-Smith and Barlow (2010) ranging from 3;0 to 3;11 and having five or six manner categories within their inventories. Cataño, Barlow and Moyna (2009) analysed the inventories of a small number of Spanish-speaking children who were two-years-old or younger and described as typically developing. A child of 11 months was seen to produce three manner categories in his inventory, whilst the inventories of three children captured at 24 months contained 4, 5 and 7 manner categories. With this in mind, it could be argued that Ben's inventories are less complex than what is expected in typical development. It seems that further analysis of the inventories compiled from word production of younger children is needed. Furthermore, it has been argued that variation occurs as the consonant inventories of different children are compared due to differences in the size of the sample of naturalistic interaction analysed. Procedures to standardise the size of the sample have been suggested to mitigate these difficulties and have led to less variety being identified (Van Severen *et al.*, 2012).

The consonants that appeared in Ben's inventories only went so far in demonstrating his speech production behaviours. In examining the range of sounds being utilised in the production of all vocalisations and the words subset, there was no indication of the degree to which they were used, and therefore their role within his overall consonant production at that age. For every session analysed, there was at least one consonant that made up over 20% of all consonants produced within all vocalisations and was therefore labelled a *highly preferred sound*. Over-reliance on a small set of sounds is seen as an indicator for phonological disorder (Dodd, 2013) but given the nature of the data collected here, it is not possible to attribute a diagnostic label such as this. Highly preferred sounds were identified within the samples of the TD group too, although they did not occur across all sessions. The key difference was that Ben had three sessions where two highly preferred sounds were found and this did not happen in the samples collected from the TD group. Amayreh and Dyson (2000) also identified highly preferred sounds in 3 of the 13 samples collected from typically developing children aged 14-24 months who were being exposed to Arabic. For these children, this degree of preference was only shown for one sound and never two. As Ben

produced vocalisations, he was reliant on a small set of sounds meaning his speech was repetitive on a segmental level as well as in terms of the word types attempted. This lack of variety was also identified with regards to the structure of the words targeted and produced.

Many of these differences could be seen as Ben falling short of his typically-developing peers' developmental advances, with more time being taken to build his lexicon, a lack of variety in the structure and meaning of the word types attempted and a narrower set of consonants being produced leading to less complex inventories. There were other differences that could be interpreted as Ben showing a greater degree of skill or more advanced development. Firstly, some of the templatic adaptations are not simplifications; rather, they result in the production of word shapes that are more complex than the target word. There are examples of monosyllabic targets being produced as multisyllabic strings, which may suggest an intention to combine multiple words together. The varied intonation patterns he displayed when producing these strings would certainly suggest that. Secondly, Ben's intra-word variability was lower than the other participants', which could be interpreted as more advanced abilities in the stabilisation of word forms and execution of phonological plans (Dodd, 2013). The differences in age range should be highlighted here, with Sosa and Stoel-Gammon (2006) finding that variability decreases with age and Ben being older than the other participants for a large part of the single-word stage due to his protracted lexical development.

In conclusion, there were aspects of Ben's development that were clearly different from the expected trajectory, but there were also similarities. Where children seem to have a limited expressive lexicon, they do not have the same opportunities to develop their phonetic and phonological abilities. Similarities between Ben and children identified as late talkers in the literature reveal that this could be a useful way of viewing his difficulties. But are there some aspects that point towards more pervasive speech and language difficulties? Recognising children who are at risk of persistent difficulties with speech and language development has implications in relation to the timing of intervention and allocation of resources (Bercow, 2018).

In the next chapter, there will be a general discussion that relates to the three preceding results chapters (Chapters 4, 5 and 6). The research questions set out at the beginning of the study will be revisited and overall conclusions will be drawn.

7 General discussion

The aim of this study was to investigate the trajectory of early speech development within a Welsh-English bilingual community. This involved examination of consonant and word production during the single-word period, and the inclusion of two language environments allowed for the role of the ambient language to be explored. The earliest developmental profiles showed the beginnings of referential word use and a range of consonants being employed across all vocalisations, as well as those identified as words. The ambient language did not seem to have a substantial effect on either the range or proportion of consonants produced, with cross-linguistic comparisons revealing a great deal of similarity across both language environments. In the context of overall similarity, there were some differences, particularly in relation to the shapes of target words attempted in each language environment, and the shapes of the children's attempts at producing them. By the end of the single-word period, the children were attempting many different words and employing a wider range of consonants within them.

The collection of longitudinal data allowed for time-related changes to be monitored. These mainly consisted of growth in the number of vocalisations, the number of words and the number of consonants produced. Changes in accuracy were also seen, as adherence to particular structural properties were monitored across the period, with group values supporting the notion that earlier word attempts are more closely matched to their targets than those produced later within the period (Ferguson and Farwell, 1975; Vihman and Croft, 2007). The identification of templatic productions in the speech of the children observed provided support for usage-based models of phonological knowledge with the starting point for the whole-word analyses that were undertaken being the sound-meaning link (Vihman and Croft, 2007). Speech production behaviours across the period were characterised by a great deal of individual variation. Variability in the production of sounds across different words provides further support for a constructivist approach to phonological development as it suggests that the children had not yet developed abstract categories for sound production. despite having the words present in their lexicons.

The children employed different strategies as they faced the challenge of word learning, however, identification of an overall trajectory was possible, in line with expectations drawn from previous literature. The opportunity to examine the speech development of a child who was not following the expected trajectory arose during the course of the study. This led to the finding that in the context of protracted lexical development, vocal output is restricted in terms of the consonants and word shapes produced, as well as the range of meanings conveyed.

The findings of this study have been presented in three chapters, each relating to a different aspect within the investigation of the developmental trajectory. Chapters 4 and 5 focussed on typical development with the former reporting on the children's production of consonants and the latter in their production of words. The aim of Chapter 6 was to present the data relating to a single case that was deemed to show atypical development. In the discussion that follows, the research questions will be answered in turn with reference to how they can be addressed by the results that have been presented in each chapter (sections 7.1, 7.2 and 7.3). In so doing, key theoretical implications will be presented in conjunction with each research question. The clinical implications of the study will then be discussed with reference to current issues within speech and language therapy (section 7.4). With the aim of considering the wider context in which these findings sit, the study's limitations will be explored and suggestions made for future research directions. The chapter will end with an overall conclusion where the overarching aim of the study will be revisited.

7.1 Research question 1 – How do phonological systems emerge during the single-word period? (RQ1)

This research question was addressed by the findings presented in Chapters 4 and 5. Examination of consonant production (Chapter 4) over time enabled conclusions to be drawn regarding the nature and rate of phonetic development. Developing the ability to accurately produce consonants is essential for children to construct a phonological system and produce recognisable words. Group trends as well as individual differences were identified initially in relation to segmental development. The nature of the sounds produced in this early stage of speech development is thought to be driven by the developing anatomy and physiology (MacNeilage, Davis and Matyear, 1997; Green, Moore and Reilly, 2002; section 2.3.3). The

sounds that characterise early speech are those found in the phonological systems of many different languages (Maddieson and Disner, 1984). Sounds can be compared to each other on the basis of how easy they are to articulate and discriminate, in relation to notions of universal markedness (Stevens, 1989). The group trends identified, through detailed analysis of the consonants produced by the participants of the study, supported this notion as the vocalisations contained a high proportion of plosives and nasals produced at the front of the mouth. The commonality of this pattern across all six participants provides further support for the influence of biological factors, which are universal and therefore not affected by the environment.

Further assertions regarding the nature of consonant production at this stage of development were possible due to the fact that these measures were taken at various points. Little variety was found in the proportions of the different consonant categories that occurred within the children's vocalisations over the course of the single-word period. That is not to say that consonant development was not taking place. The children extended their use of individual consonants throughout the period, with session on session growth seen in the number of consonants listed in each child's inventory. The number of consonants in a child's inventory relates to the number of different ways they are able to manipulate the airstream leaving their lungs as they phonate (Davenport and Hannahs, 2010). Previous studies that have investigated consonant production in this period have reported that the range of consonants used by a child increases over time (Stoel-Gammon, 1985; Robb and Bleile, 1994; Amayreh and Dyson, 2000; Vihman, 2014). The increase in the range of consonants produced was observed whether all vocalisations were taken into account (e.g. Robb and Bleile, 1994) or analysis was limited to the vocalisations identified as words (e.g. Stoel-Gammon, 1985). Robb and Bleile (1994) argued that in order to get a true representation of the child's phonetic abilities, all vocalisations should be included. It seems that decisions regarding which vocalisations to include when compiling phonetic inventories should be related to the specific aims of the study. Inventories compiled based on words only are more indicative of phonological development, as they allow for conclusions to be drawn regarding which of the motoric gestures available to them are being utilised to convey meaning.

The individual trajectory of consonant development was also evaluated in relation to inventory complexity. Several other researchers have examined consonant inventory complexity in both monolingual and bilingual children (Cataño, Barlow and Moyna, 2009;

Fabiano-Smith and Barlow, 2010; Montanari *et al.*, 2014; section 2.5.1; Dinnsen *et al.*, 1990). The hierarchical framework put forward by Dinnsen *et al.* (1990) is based on the application of the theoretical notion of implicational hierarchy to children's speech. Within this framework, there are five levels on which the complexity of children's phonetic inventories can be evaluated, providing an objective way of comparing complexity across children and language environments. Previous studies on inventory complexity have generally featured older children at a later stage of speech development than the participants of this study. For the purposes of this study, an increase in the number of manner classes present within the inventories compiled was taken as an indicator of increasing complexity. Based on this metric, inventory complexity was seen to increase over the course of the period in line with what was seen when the inventories recorded within previous research were evaluated in this way (this was discussed fully in 6.5.3 in relation to decisions regarding what is typical in terms of inventory complexity; aspects that could allow for recognition of typical and atypical development are going to be discussed further in 7.3 below).

Over the course of the single-word period, there was an increase in the range of consonants and the number of different manner categories produced. At the same time, the proportions of place and manner categories remained the same. It can therefore be seen that the production of any new consonants or consonant types was in line with the overall patterns of consonant use. In other words, each child was extending their consonant use and mastering novel consonants but taken as a whole the proportions did not substantially change over the course of the period. This has implications in terms of whether the nature of consonant production is viewed on an individual or group basis.

In the context of overall similarity across the children studied and across the time period under investigation, it was clear that the children were learning to produce their consonants according to individual motivations. Preference for certain sounds or sound classes were seen for several of the participants, which supports previous work where individual difference in consonant production has been found (Stoel-Gammon, 1987; Velleman and Vihman, 2002; Keren-Portnoy, Majorano and Vihman, 2009). For example, the strong preference for approximants in Beca's data was observed when comparing the frequency of occurrence of her manner categories with that of the other TD children (section 4.3.1). This preference was also illustrated by the prevalence of [j] in her preferred sounds (section 4.4) and her use of the <hVjV> template over several sessions (section 5.3.4). During the single-

word stage, children utilise familiar articulatory routines in their quest to convey meaning through word production (Velleman and Vihman, 2002; Vihman, 2017; Vihman and Croft, 2007).

The emergence of the phonological system cannot be characterised by examination of the consonants alone. Examination of word production (Chapter 5) over time enabled further conclusions to be drawn regarding the rate and nature of speech development. Investigating word production behaviours provided an opportunity for observation and evaluation of phonological abilities. According to the constructivist theoretical stance taken in this thesis and discussed throughout, this is a system built through use with repeated experience with certain structures, both in perception and production, leading to the creation and stabilisation of representations which are drawn on during word production (Vihman and Velleman, 2000; Bybee, 2001; Fikkert, 2006; Vihman, 2016). There was a similar distribution of consonants across all vocalisations and words, suggesting that the sounds used frequently overall were the ones being utilised in children's early word productions. Some aspects did not support this notion, however. Consonants labelled as preferred (over 10% of all consonants produced) and highly preferred (over 20%) in all vocalisations were not always the same as those identified within the subset of vocalisations identified as words. It could be surmised that this was driven by lexical motivations. Some articulatory routines favoured in the production of pre-speech and early speech may not align with the requirements of the ambient language (Robb and Bleile, 1994). In fact, in the pursuit of a complete phonological system, a reduction in reliance on motoric gestures that are familiar is required in order for all the necessary representations to be mapped. This was seen here as preferred sounds were less common as the children progressed through the single-word period (section 4.4).

The single-word period mainly contained target words that were relatively simple in their structure, with mono- or disyllables containing an onset and an open final syllable being the most frequently attempted by all children. There were some differences identified that could be related to the language of the environment, but that is discussed further in section 7.2, where the second research question relating to the role of the ambient language is addressed. Children have been described as selecting their early lexicon based on their existing speech production abilities (Stoel-Gammon, 2011). Syllables with a CV structure are certainly seen to be among the easiest to produce, with links being drawn once again to the routines

practised during canonical babble and the biological underpinnings of speech development (section 2.3.3).

First words tend to be closely matched to their targets with a subsequent reduction in accuracy seen as children attempt to produce a wider range of word types, but are restricted by limitations of their developing speech production abilities. This has led to the identification of a U-shaped curve in relation to the accuracy of word production over time (Ferguson and Farwell, 1975). Where the children's vocalisations could be matched to referents within the environment, judgements were made relating to whether the child's attempt to produce a word matched the target on the basis of specific structural properties. It was shown that the findings of this study did not refute the notion of a U-shaped curve, with the degree of match to the target decreasing towards the middle of the period on a number of parameters, including syllable number and the presence of a coda. This trend was more readily observed for the English environment group, with the Welsh environment group showing greater fluctuation in terms of adherence to the structure of the target words across the period under investigation. This could have been due to differences in the spacing of sessions captured in each of the environments (this is discussed further in section 7.5).

Phonological development begins at the pre-linguistic stage when children learn to segment the speech stream they are hearing into perceptible parts (Kuhl *et al.*, 2005). Within this study, the observation of phonological learning began as the children started to use words, shortly after their first birthday. The emergence of the phonological system was observed as they put into practice the implicit knowledge they had gained through procedural learning during speech perception and early production practices and began to produce words. Application of the templatic approach (Vihman and Croft, 2007) allowed for illustration of this process as selected and adapted forms were identified in the samples collected from all four of the participants subjected to these analyses. What is important in relation to addressing RQ1 is that this study provided support for the usefulness of the templatic approach in examining the nature of word production and the underlying mechanisms involved. Children have been shown to be at the height of their template use as they expand their vocabularies from 50 to 100 words (Vihman, 2017). This study has allowed for the period before, when template use is just beginning, to be examined in detail, thus demonstrating that investigation of emerging systems can also lend support to a constructivist approach to phonological development.

The rate of speech development, as demonstrated by growth in the number of consonants, word types and progression towards the establishment of a phonological system is variable across the children studied. Differences in rate of development between monolingual and bilingual children have been widely documented (section 2.5.3). Due to differences within the participant group in relation to home language use patterns, such comparisons could be possible here. Beca was experiencing a dual-language home and therefore the amount of input in each of her languages was considerably less than Gwen, Gwawr, Eve and Ed who were experiencing single home language environments. Previous research has revealed that these types of differences can lead to patterns of positive or negative transfer in relation to the rate of development (Goldstein and Bunta, 2012). Through comparison of the sessions captured in the Welsh environment, Beca's lexical development was more protracted than that of Gwen or Gwawr. However, for the sessions where English was the language of the environment, Beca's rate of development was in line with that seen for Eve and Ed. Despite this variation across children and language environments, it was clear to see that all of these children's speech development could be described as being within what is expected for typical development (with Ben's trajectory deviating from this and therefore being discussed separately; see section 7.3 below for further discussion of typical and atypical speech development). When looking across the TD group, Beca's development aligned to two of the four other participants. Linguistic experience did not seem to be a factor here; however, it just so happened that these were experiencing an English home language environment.

To summarise the response to RQ1, this study demonstrated the emergence of the phonological system through the study of consonant development as well as patterns seen in the production of early words. The single-word period is characterised by a preponderance of plosives and nasals and a reliance on relatively simple syllable structures. Vocal behaviours adopted during the pre-linguistic stage are practiced as children make early attempts to convey meaning provide the basis for the development of their phonological system or systems.

7.2 Research question 2 – What is the role of the ambient language in the production of consonants and early words? (RQ2)

Elements of the data presented in all three results chapters can be utilised in addressing RQ2, as the ambient language influence can be seen in the production of consonants and words in typical and atypical development. Aligning aspects of speech production with characteristics pertaining to the ambient languages involved goes some way towards disentangling factors within this process which could be considered universal, language-specific and child-specific (Velleman and Vihman, 2006). This is particularly true where children's vocal production behaviours deviate from expectations driven by what is common amongst the world's languages, and therefore supported by principles of typological markedness (this is discussed in response to RQ1, above and is introduced in section 2.3.3). This study compared the early speech production behaviours of children being exposed to two different codes, which allowed for cross-linguistic comparisons, both within- and between-child.

Another important consideration in the context of this study is cross-linguistic influence. Its significance is two-fold. Firstly, it should be considered in terms of examining the synchronic transfer between the emerging phonological systems of the children experiencing dual-language input. Secondly, it needs to be discussed when comparing phonological development in children receiving dual- and single-home language input. However, there is a great deal of overlap between the sound systems of Welsh and Welsh English, which means it may be difficult to ascertain the extent of ambient language influence (Mayr *et al.* 2017; Mennen *et al.* 2020; Penhallurick, 2004). It is important that such language-internal factors are considered as the role of the ambient language is discussed (Kehoe and Havy, 2019). Studies attempting to provide evidence for the effect of the language of the environment on the development of speech production abilities need to make these evaluations based on perceptible differences between the two languages.

As far as consonant development is concerned, the children's vocalisations contained a range of consonant types and they were produced at similar proportions across both language environments. There are several possible reasons for this similarity. Firstly, it could be explained in relation to the universals of phonological acquisition, by putting forth the notion that consonant production at this stage of development is more strongly influenced by universal factors than those pertaining to the language of the environment (this is discussed in

7.1, above). Secondly, phonological transfer between the two languages could have led to the similarities seen within the consonantal inventories. The data presented could be drawn on as evidence for synchronic transfer, as the similarities were present in the consonants produced by children from dual-language homes so their experience of both languages and interaction between the emerging systems could have led to similarities in their production of consonants and word shapes across Welsh and English. The similarity could also be a result of historical convergence, with transfer having taken place in the speech of Welsh-English bilingual speakers in the past creating a lasting "integrated Welsh influence" (Jones, 1990, p. 196).

There are differences in the segmental and supra-segmental characteristics of Welsh and English (see 3.2.3 for a description of these). A focus on the presence of additional consonants in the Welsh phonological system could allow for identification of cross-linguistic influence however, /ɬ/ and /χ/ are later acquired sounds for children regardless of home language background (Ball, Muller and Munro, 2001; Munro *et al.*, 2005) so it was not possible to examine this aspect here. Variation in the production of the /r/ phoneme has also been called upon to examine cross-linguistic influence (e.g. Morris, 2021; Morris, Mayr and Mennen, 2016). But given that there would be no expectation that this category would be formed yet for the participants of this study, as it is again later acquired (Munro *et al.*, 2005), this feature could not offer an opportunity to observe interaction or separation of the systems.

Alongside segmental similarity, particularly when looking at consonants that appear in early phonological development, Welsh and English differ in terms of certain phonotactic and prosodic features (section 3.2). The study of word production in each of these environments allowed for further cross-linguistic comparisons to be made. By examining the target words selected by each of the participant groups, it was possible to identify language-specific differences which suggested environmental influence. With reference to the learning mechanism outlined in section 2.2, children attend to the regularities within the input they are hearing and those gaining experience of two codes are able to differentiate between them (Byers-Heinlein and Fennell, 2014). Through this intrinsic learning mechanism, their perception and production abilities are honed, in accordance with the needs of the language or languages they are learning. This can be seen through examination of the frequency of disyllabic target words across the two environments. Disyllables are common amongst early words in many of the world's languages (Garmann *et al.*, 2019). There was a higher

incidence of disyllabic targets in the Welsh environment, as compared to the English environment. Therefore, the lower occurrence of disyllabic targets in the English environment could be taken as evidence of ambient language influence. The same could be said for the higher likelihood for targets in the English environment to contain a coda. Studies have shown that children select their target words due to their own motoric abilities (e.g. Ferguson and Farwell, 1975). If these motoric abilities match the prevalent characteristics of the language input they are receiving then it follows that the target words that they select may reflect language-specific tendencies.

The medial consonants in Welsh, for example, have been described as having increased salience due to the lengthening that occurs as a feature of accent (Mennen *et al.*, 2020; Williams, 1983; Williams, 1985; Williams, 1999). This has led researchers to draw comparisons between Welsh and languages that contain medial geminates, such as Finnish (e.g. Velleman and Vihman, 2006). Children learning these languages have an increased occurrence of initial consonant omission as compared to English and other trochaic languages. As CV consonants are supposedly the most common, unmarked and early acquired of structures, the presence of initial consonant omission provides support for the influence of linguistic factors on the development of speech production abilities. The different ways in which target words containing onsets and codas were dealt with across the two languages studied here provides support for the effect of the ambient language on word production practices of these participants. This shows that even at this young age and early stage in linguistic advancement, language-specific aspects can be identified. It has been suggested that the influence of the ambient language increases as children go beyond the single-word stage and extend their lexicon from 50 to 100 words (Velleman and Vihman, 2006). These findings suggest that ambient language influence can be identified at this early stage in relation to certain structures.

The importance of consideration of language-internal factors, such as shared phones and similar rhythmic qualities, has been widely documented (e.g. Kehoe and Havy, 2019). What has been identified as being important here is consideration regarding the varieties of languages that exist within bilingual communities. Where languages have been in contact for long periods, changes in the segmental or prosodic make-up of one or both languages over time may have a bearing on the magnitude of some of the language-internal effects. Also, a lack of a monolingual Welsh population means it is difficult to view the languages separately

(Mayr *et al*., 2017). This could be the case for Welsh and Welsh English. Where cross-linguistic comparisons are being made, it is highly pertinent to consider sociophonetic factors as the difference under evaluation may not be so apparent in the contact variety. This is the case for medial consonant lengthening, which is a feature of Welsh English as well as Welsh (Mennen *et al.* 2020).

The similarities across Welsh and Welsh English are also relevant to the discussion of differentiation and interaction within the two participants who are experiencing dual language input. Within-child comparisons revealed that the consonant production of children experiencing Welsh-English dual-language exposure is similar across both environments in terms of the frequency of occurrence of place and manner categories. Differences were identified in the range of consonants produced in each environment by both Beca (typical development) and Ben (atypical development). There were also differences in the usage patterns of the various consonants, as demonstrated by the differences in preferred and highly preferred sounds (section 4.4). Taken together, these findings indicate that there were cross-linguistic differences in the nature and rate of consonant development but that this did not have a substantial effect on the overall proportion of place and manner categories. The differences identified could be partially explained by language-external factors such as the influence of the size of the lexicon (Kehoe and Havy, 2019). For Beca, differences in the patterning of preferred sounds was seen to be related to differences in the lexical items attempted across each language environment.

There were some cross-linguistic comparisons made within the analysis of word production where the data from children with dual-language homes did not align with the group trends. This was in relation to the way in which the presence or absence of both onsets and codas were approached by the children. Differences had been identified in the group data, with the proportion of target words containing a coda that were produced with a coda being higher in English and the proportion of target words not containing an onset that were produced without an onset being higher in Welsh. But for Beca and Ben, the same proportion of target words with codas were produced without a coda in both environments and the same could be said for target words without an onset. This could therefore be described as interaction between the developing systems. At this stage in development, which has been defined as being up until the children reach the 25-word-point and are therefore deemed to have approximately 50 words in their lexicon, phonological systemisation is just beginning

(DePaolis, Vihman and Kunnari, 2008; Kunnari, 2002; Vihman, 1993; Vihman and Velleman, 2000; this is discussed in the previous section where RQ1 is addressed). This means that any discussions surrounding interaction between the systems need to be considered in the context of incipient systems.

With reference to bilingual children and the emergence of phonological systems, the templatic approach has also been applied to bilingual development (Kehoe, 2015; Vihman, 2016; Vihman, 2002). The study of template use in bilingual children provides an opportunity to explore the influence of language-specific characteristics, either segmental or structural, across the two languages the child is learning. Vihman (2002), for example, demonstrated similar template use across French and English by Tom, whose data were presented in Brulard and Carr (2003). In this study, cross-linguistic similarity was seen in relation to template use with examples of addition and omission of syllables, onsets and codas being seen in both Welsh and English environments. Beca and Ben, who were experiencing dual-language exposure, employed similar templates across each of their language environments which supports previous findings related to template use in bilingual children. As the patterns of template use did not differ between the children experiencing single- and dual-language homes, it could be surmised that cross-linguistic differences were better explored by quantification and comparison of adaptation patterns, as shown in the latter parts of Chapter 5 (i.e. sections 5.3 – 5.5) where the proportion of matches between the target words and word production attempts were documented for syllable number was well as onset and coda patterns.

To summarise the response to RQ2, the role of the ambient language was apparent when between-child comparisons were made, particularly in relation to the structure of words targeted and the children production attempts. In the context of language contact, it is important to consider the role of language-internal effects which could obscure differences that may otherwise be apparent. In this study, comparisons made based on the percentage occurrence of structures related to the three chosen properties (syllable number, onsets, codas) were more useful in determining the role of the ambient language than comparison of the specific templates utilised.

7.3 Research question 3 – How does identifying the trajectory of speech development in the single word period support the examination of atypicality? (RQ3)

This research question was addressed mainly by the results presented in Chapter 6 where the focus was on atypical development, through the study of Ben's case. The insights that had been gained through the examination of the developmental trajectory of the TD children (Chapters 4 and 5) allowed for comparisons to be made. The key outcomes of these comparisons were related to the perceived similarities and differences between Ben's developmental profile and those identified in relation to the other five participants. It was seen that whilst Ben's trajectory of development did deviate from that of the TD group on a number of parameters, careful consideration of the data revealed that his vocal behaviour was in line with that of the other 5 participants in a number of ways (these were discussed in section 6.11).

The opportunity to study speech production at such an early age, before concerns regarding the rate of his development had been raised, allowed for retrospective analysis of those first steps of linguistic advancement, with a view to identifying the presence of possible predictors of his later difficulties. Early identification of speech and language difficulties allows for the timely provision of intervention programmes, which, in turn, can lessen the negative implications of such difficulties, both socially and educationally (Bercow, 2018).

Ben's output was characterised by a lack of variety which was apparent through study of the consonants, word types and word shapes he produced throughout the period. In relation to the existing systems for classification of speech sound difficulties, more information would be needed regarding Ben's abilities for them to be utilised. To apply Dodd's classification system (Dodd, 2013), there is a need to identify error patterns and make decisions regarding whether the errors identified are found within typical development for the relevant ambient language or not. Some error patterns such as reduplication and final consonant deletion were identified in Ben's sample as well as within the samples collected from the members of the TD group. However, in order to complete a full analysis of error patterns, a variety of vocabulary items would need to be elicited and at that stage of development, the required degree of lexical diversity was not there. Assessments that are aimed at eliciting data in order to look for these error patterns are aimed at older children, who have more varied

vocabularies. Also, the typical trajectories for the majority of these error patterns relate to ages that are greater than 2;6 (Dodd *et al.*, 2003). The speech processing model (Stackhouse and Wells, 1997) may be able to offer some insights into Ben's underlying difficulties. A more detailed assessment of his abilities would be needed to take full advantage of this hypothesis testing approach where it may be possible to discern whether Ben's difficulties are due to problems with phonological representation or motor programming.

In order to evaluate Ben's speech production, there is a need to draw on studies that have focussed on the recognition of speech difficulties in younger children, referred to as *toddlers* (Stokes and Klee, 2009; Scherer *et al.*, 2012; Hodges *et al.*, 2017). These studies demonstrate that it is possible to elicit word production from toddlers. Hodges *et al.* (2017) examined the responses made by children aged between 25 and 35 months in response to two tasks: object naming and non-word repetition. What was interesting about their study was the focus on what happened when elicitation of the target words or nonwords was unsuccessful; in those cases, the responses either involved silence, the production of a generic protoword or the production of a different word. Ben repeatedly used the limited range of words he was able to produce for purposes of commenting, responding and questioning. There was a very high occurrence of 'yes' and 'no' and jargon strings that he utilised with varying intonation in order to convey particular meanings. These jargon strings, which could be likened in some respects to the protowords described in the study by Hodges *et al.* (2017), were often used in conjunction with the recognisable words he produced often. What usually followed was a suggested interpretation by one of his parents, which he then accepted or rejected. This was how meaning was constructed between Ben and his parents within the recorded play sessions. The recognition of typical or atypical speech and language development is based on careful observation of communication occurrences. Ben made regular contributions to the conversation and was able to make his needs known due to his attentive and familiar interlocutors. It seems that the ways in which children respond when prompted or questioned needs to be taken into account and can be useful in predicting persistent difficulties.

Vihman and colleagues argue that the utilisation of templates in speech production and the adaptation of novel words to existing motoric routines signals the emergence of the phonological system (section 2.3.4). In the context of protracted lexical development, the beginnings of systematisation can be seen in Ben's productions across both language environments. In general, adapted forms were identified later for Ben as compared to the

other 5 participants. At the end of the data collection period, when he is nearly two and a half, his phonological system had begun to emerge. His use of templates is similar across the two language environments with several structural patterns identified as well as a tendency to use particular segments, namely [h] and [ʔ] in this word production attempts. Only a small number of studies have applied the templatic approach to atypical development. Velleman and Vihman (2002) considered implicit and explicit learning in relation to children with various speech sound difficulties, suggesting that deficits in either or both can lead to reduced intelligibility. Ben's vocal production was characterised by the repeated use of a narrow set of sounds and structures, leading to widespread homonymy. The development of appropriate phonetic and phonotactic repertoires is said to be dependent on successful implicit learning mechanisms. It could therefore be suggested that Ben had difficulties attuning his perceptual and production abilities to the aspects of the speech stream specific to the languages of his environment. The apparent mismatch between what he understands and is able to express may indicate that he has knowledge of the relevant vocabulary and concepts but is unable to successfully convey meaning due to his "limited repertoire of productive word shapes" (Velleman and Vihman, 2002 p. 18).

Dual-language exposure has been shown to influence the rate and nature of phonological development (sections 2.4 and 2.5.3). The identification of atypical patterns in the context of bilingual development has important clinical implications, these are discussed further in section 7.4. In Ben's case, it seems his phonological systems are just emerging and therefore it is difficult to draw conclusions regarding the degree of differentiation between his two languages.

To summarise the response to RQ3, the study of the five children belonging to the TD group allowed for mapping of the developmental trajectory within this specific population. This resulted in an increased awareness of what is typical, allowing for the identification of the specific aspects of Ben's speech development that differed from the other children, namely a reduction in segmental and structural variety. Identification of atypicality at this early stage of development depends on detailed analysis of the vocalisations produced. In addition, the attempts made to convey meaning need to be examined to see whether the child is attempting to produce recognisable words or something else, such as protowords or jargon. When exploring the influence of bilingual exposure at this early stage of linguistic development, it is important to acknowledge that phonological systematisation has only just begun.

7.4 Clinical Implications

Speech and language therapists draw on normative data in order to identify and classify speech sound difficulties (Joffe and Pring, 2008). The speech production of Welsh-English bilingual children has not been widely studied, particularly in relation to this early stage of development. This means that information required for effective decision-making is not readily available. There is therefore a risk that decisions could be made based on incomplete information or data relating to monolingual populations. This study has provided some insights into what happens during the single-word stage and can therefore be seen to add to the findings reported in Munro *et al.* (2005) and Mayr, Howells and Lewis (2015) and Mayr, Jones and Mennen (2014) where the youngest participants were 2;6. Drawing conclusions relating to the rate and nature of development for consonants and words for children residing in a Welsh-English bilingual community has implications for the development of tools to identify and address speech sound difficulties relating specifically to the linguistic experience of many children in Wales. These insights can also be extended further to other children residing in communities where languages are in contact.

Given that differences were found when the abilities of children experiencing dual-language exposure was compared across their languages, the importance of evaluating development across all languages present in a child's life is supported by the findings of this study. The risks associated with limiting the assessment of speech and language abilities to one language, usually the majority language, have been widely documented (Kohnert, 2013). Had Ben's abilities only been viewed in terms of his vocal behaviour in the English environment, this would not have been a true representation of his skills overall. It is important that bilingual children are given the opportunity to showcase their skills in a variety of linguistic environments and that this is offered to all children, without exception.

The relationship between lexical and phonological development has been widely discussed in the literature, with delay in early language development being associated with speech sound disorder (Eadie *et al.*, 2015; Wren *et al.*, 2016). Within typical development, there is also a need to consider a child's speech production behaviour in accordance with their lexical development (Stoel-Gammon, 2011). Within this study, the participants were often compared based on the numbers of word types produced within the session (i.e. word-stage category) rather than their age. Given the assertion that phonological knowledge is gained

through use, it follows that the numbers of words in a child's lexicons has a bearing on the advancement of their phonological skills. In terms of the evaluation of children who have been identified as having possible speech and language difficulties, there is often an emphasis on the age at which particular speech behaviours should appear or disappear (e.g. Dodd *et al.*, 2003). In the context of this early stage of speech and language development, it seems that the stage of lexical development should be taken into account when deciding on whether a child's speech production behaviours are in line with their peers'. Furthermore, the evaluation of children's difficulties should take into account the individual nature of speech development at this stage.

7.5 Limitations of the study

In order to address the aim of the study, it was necessary to recruit suitable families and maintain their involvement over a substantial period. Due to the development of speech and language skills being highly influenced by the nature of the language input a child has, careful consideration was given to potentially influencing factors such as patterns of language use within the home, the gender of the speaker of each language and whether they were the primary caregiver. Attempts were made to match participants based of these factors whilst keeping in mind the need to group the children as 'only Welsh at home', 'only English at home' and 'Welsh and English at home'. However, as recruitment began, it was clear that participation in this study would mean a great deal of commitment from the families involved. In order for multiple recording sessions to take place at regular intervals, the parents were required to balance the competing demands of busy home and work lives. In many cases, the participants had siblings; therefore there was a need to ensure that other children were not around during filming so that the interaction could be limited to the child and the parent. For the dual-language homes, two recording sessions were scheduled at each data point, substantially increasing the time commitment and organisation needed. During the conversations that happened within parent groups during the recruitment phase, many of the families that were approached did not feel able to offer this level of commitment for the duration of the data collection period.

Almost all of the parents that did express an interest in being part of the study were accepted. It was not possible to control for all variables that influence the nature of language input and

therefore some of the factors featured more heavily in decisions of who to include e.g. patterns of language use within the home was prioritised above the child being first-born. For bilingual homes following a 'one parent one language' approach, there was a potential for differences in the nature of the input provided by each parent to obscure cross-linguistic differences that may exist. In the case of the bilingual households included in this study, parents consisted of a male and a female so the influence of gender on interaction styles and the nature of language input could have been a factor (section 2.4.2). However, for Ben and Beca, their mothers were providing the Welsh input, and their fathers were providing the English input, so they were comparable in this regard.

In order to investigate the developmental trajectory of a group of children and make comparisons, data collection needed to be collected at regular intervals. It was not possible to specify the exact age of the children at the time of recruitment, although efforts were made to ensure that their age at the time of first recording was below 15 months. Previous studies have compared children on the basis of a specific word-point but here it was not uncommon for a child to make substantial gains in the numbers of word types they produced across two consecutive sessions. This meant that matching sessions to particular word points was not possible and word-stage categories were created instead (section 4.2.1). The word-stage category boundaries were set so that as many of the participants as possible were represented within each stage.

In terms of the data collection process, the technical set-up was carefully designed to allow for high quality recordings of the children's vocalisations to be produced. However, the presence of the researcher, the need to have recording equipment in the same room, and the need for them to wear a cloth vest that was unfamiliar to them at times proved challenging (section 3.5). Also, keeping a child of that age engaged in play activities for 50 minutes at a time was a challenge and therefore the parents needed to employ a range of distraction and diversion techniques. There was a need to maintain the child's focus away from the researcher and the recording equipment as the play activities were facilitated by the parents. This meant that sessions and parts of sessions needed to be disregarded. This, along with the cancelling of arranged sessions due to illness or other unforeseen circumstances, led to data sets that were incomplete. This was mitigated somewhat by the decision to disregard some participants when their data sets did not contain sufficient sessions relating to the single-word

period. Thus, for the six participants chosen for analysis, there were multiple sessions recorded that related to the period in question.

7.6 Future research

The focus of this study has been speech development in the single-word period within children residing in a bilingual community. A logical avenue for future research would be to investigate what happens beyond this point, when children further expand their vocabulary and produce word combinations. The findings described in this thesis provide support for the presence of a U-shaped curve, seen to be a feature of development at this age, but due to the fact that analysis was stopped once the 25-word-point was reached, it was not possible to fully track whether the decrease in accuracy brought about by adoption of templates was followed by an increase in accuracy as the children's productions became more in line with the adult target.

An important part of the data analysis process was the separation of words from non-words. The subset of vocalisations deemed to have word status was then subject to further investigation, including the identification of templates. Future research could include a focus on identification of VMS and the resulting templates in the non-words produced alongside the word productions. It has been suggested that for children with phonological disorders, close inspection of their jargon utterances can assist in the identification of templates (Velleman and Vihman, 2002). It may be that extending the identification of templates to all vocalisations and not limiting the analysis to those categorised as words would provide further insights into the underlying learning mechanisms and motivations of children at this stage of development.

This study featured words produced by children within a naturalistic setting with no attempts made to elicit particular vocabulary items. Given that cross-linguistic differences were found relating to onsets and codas, future work could include the elicitation of specific target words where these structural properties were present or absent in order to investigate these differences further. Further illumination of the cross-linguistic differences could also be gained through consideration of possible differences in the relative frequency of occurrence of segmental and structural characteristics across Welsh and English. Analysis of existing corpus data (e.g. Bangor Siarad Corpus, CEG) to gain frequency values for Welsh would

allow for these comparisons to be made. Also, a new corpus has recently been made available that features a large body of instances of contemporary Welsh (CorCenCC, Knight *et al.*, 2020). Systematic searches of this corpus from the perspective of the consonants and syllable shapes that are frequently occurring in Welsh would allow for cross-linguistic differences in the early speech patterns used by children to be related to the nature of the input they are hearing.

7.7 Conclusion

This study sought to discover how the examination of vocalisations produced by children residing in a bilingual community adds to our understanding of early phonetic and phonological development. A bilingual community typified by various language use patterns within the home was chosen as the setting and children just embarking on their language acquisition journey were recruited to take part. At this stage of development, children are building the foundation for their future speech and language abilities. Close examination of the vocalisations they are producing, with consideration of both time and ambient language variables, allowed for conclusions to be drawn regarding the trajectory of early speech development within this Welsh-English bilingual community.

This study firstly took the form of consonantal analysis. Examination of the consonants produced by the six participants within their vocalisations allowed for assertions to be made regarding the rate and nature of consonant development during the single-word stage. It was found that all six children added to their consonant inventories as they got older, with five of the six children displaying a similar rate of growth across the period and one child displaying slower development over a time period that was far longer. The consonantal make-up of their vocalisations was in line with what is expected in early speech development and this did not vary according to the language of the environment. Cross-linguistic similarity was seen across Welsh and English environments between- and within-child comparisons were made.

The second focus within this study was word production within the single-word period. The vocalisations categorised as words were subject to further analysis where the structural properties of both the adult forms being targeted and the production attempts made by the children were examined. Where syllable number was concerned, there was a greater

tendency for monosyllabic words to be targeted in the English environment and disyllabic words to be attempted in the Welsh environment. Study of the degree of adherence to the syllable number within the target showed that this was more likely for mono- and di-syllabic targets than multi-syllabic targets. As the children moved into the middle of the single-word period, there appeared to be an initial decrease in the degree of match between the syllable number contained in the target word and the child's production attempt. Towards the end of the single-word period the degree of match increased, suggesting that greater phonetic and phonological skill was being achieved, resulting in a greater ability to produce the required number of syllables. For onset and coda patterns, cross-linguistic differences were also identified with more attempts at no onset targets in the Welsh environment matching their targets in this regard. The same could be seen for attempts at no coda targets in the English environment. Once again, some evidence for a U-shaped curve in development was seen but analysis of sessions beyond the 25-word-point would be needed to fully support this conclusion.

Although not an initial aim of the study, examination of atypical development also became possible when one of the participants recruited was identified as having atypical speech and language patterns. The growth of his lexicon was far slower and so more time was taken for him to reach the end of the single-word period. The analyses conducted in relation to the participants belonging to the typically-developing group allowed for assertions to be made regarding the expected developmental trajectory of phonetic and phonological development for children residing in this community. What was interesting about studying the development of this child was the identification of similarities between him and the typically-developing participants. This raises questions regarding the nature of speech sound disorders at this age, particularly in relation to children who could be described as late talkers. The identification of children likely to display persistent speech and language difficulties is vital in order for the timely provision of intervention. This study goes some way in describing a developmental path that did not conform with generally held expectations surrounding speech and language development. What was even more notable, given the lack of studies that feature atypical bilingual development, was that this child was experiencing a dual-language home.

The accumulation of phonological knowledge through use was a prominent theme within this thesis. Underpinned by biological and linguistic factors, implicit and explicit learning was

examined through the identification of templates across typical and atypical development. Word production patterns were quantified to allow for the examination of patterns of omission and addition of syllables, onsets and coda. These patterns were then illustrated through the identification of templates in the children's individual samples. This study provides support for the existence of templates in the early word productions of Welsh-English bilingual children, across single- and dual-language homes. As words were added to their developing lexicons, widespread template use was evident. Taken together with the decrease in structural accuracy seen towards the middle of the period studied, this suggests that at the expense of accuracy children adapt novel target words to fit with existing motoric abilities.

Detailed longitudinal analysis of vocal behaviour in a small group of children has added to what is already known regarding the nature of early phonetic and phonological development. The study of two separate language environments has allowed for conclusions to be drawn regarding the role of the ambient language. For early phonetic and phonological development in a bilingual community to be fully understood, there needs to be appreciation of the multi-faceted nature of the task that is faced by children at this stage. Both external and internal factors need to be considered as the developmental trajectory is mapped, with an acknowledgement that this whole process is characterised by individual differences.

References

Amayreh, M. M. and Dyson, A. T. (2000) 'Phonetic inventories of young Arabic-speaking children', *Clinical Linguistics & Phonetics*, 14(3), pp. 193-215.

Anderson, J. L., Morgan, J. L. and White, K. S. (2003) 'A statistical basis for speech sound discrimination', *Language and Speech*, 46(2-3), pp. 155-182.

Andruski, J. E., Casielles, E. and Nathan, G. (2014) 'Is bilingual babbling language-specific? Some evidence from a case study of Spanish–English dual acquisition', *Bilingualism: Language and Cognition*, 17(3), pp. 660-672.

Anthony, J. L., Aghara, R. G., Dunkelberger, M. J., Anthony, T. I., Williams, J. M. and Zhang, Z. (2011) 'What factors place children with speech sound disorders at risk for reading problems?', *American Journal of Speech - Language Pathology*, 20(2), pp. 146-160.

Ball, M. J., Howard, S. J. and Miller, K. (2018) 'Revisions to the extIPA chart', *Journal of the International Phonetic Association*, 48(2), pp. 155-164.

Ball, M. J., Muller, N. and Munro, S. (2001) 'The acquisition of Rhotic Consonants by Welsh-English bilingual children', *The International Journal of Bilingualism*, 5(1), pp. 71-86.

Ball, M. J., Müller, N. and Munro, S. (2006) 'Phonological development and disorder of bilingual children acquiring Welsh and English', in Hua, Z.H.U. and Dodd, B. (eds.) *Phonological Development and Disorders in Children: A Multilingual Perspective*. Clevedon: Multilingual Matters, pp. 346-382.

Ball, M. J. and Williams, B. (2001) *Welsh Phonetics.* Lampeter: Edwin Mellen Press.

Beckman, M. E. and Edwards, J. (1994) 'Articulatory evidence for differentiating stress categories', in Keating, P.A. (ed.) *Phonological Structure and Phonetic Form. Papers in Laboratory Phonology III*. Cambridge: Cambridge University Press, pp. 7-33.

Beckner, C., Blythe, R., Bybee, J., Christiansen, M. H., Croft, W., Ellis, N. C., Holland, J., Ke, J., Larsen-Freeman, D. and Schoenemann, T. (2009) 'Language is a complex adaptive system: Position paper', *Language Learning*, 59(1), pp. 1-26.

Bedore, L. M., Peña, E. D., Summers, C. L., Boerger, K. M., Resendiz, M. D., Greene, K., Bohman, T. M. and Gillam, R. B. (2012) 'The measure matters: Language dominance profiles across measures in Spanish–English bilingual children', *Bilingualism: Language and Cognition*, 15(3), pp. 616-629.

Bell, E., Archangeli, D. B., Anderson, S. J., Hammond, M., Webb-Davies, P. and Brooks, H. (2021) 'Northern Welsh', *Journal of the International Phonetic Association*, pp. 1-24.

Bellin, W. (1984) 'Welsh phonology in acquisition', in Ball, M.J. and Jones, G.E. (eds.) *Welsh Phonology: Selected Readings*. Cardiff: University of Wales Press, pp. 156-175.

Bercow, J. (2018) *Bercow: Ten Years On*. Available at: bercow10yearson.com.

Best, C. C. and McRoberts, G. W. (2003) 'Infant perception of non-native consonant contrasts that adults assimilate in different ways', *Language and Speech,* 46(2-3), pp. 183-216.

Bijeljac-Babic, R., Serres, J., Höhle, B. and Nazzi, T. (2012) 'Effect of bilingualism on lexical stress pattern discrimination in French-learning infants', *PLoS One*, 7(2).

Boersma, P. and Weenink, D. (2016) *Praat: doing phonetics by computer [Computer Programme]. Version 6.0.23*. Available at: www.praat.org.

Bosch, L. and Sebastian-Galles, N. (2001) 'Evidence of early language discrimination abilities in infants From bilingual environments', *Infancy*, 2(1), pp. 29-49.

Bosch, L. and Sebastián-Gallés, N. (1997) 'Native-language recognition abilities in 4-month-old infants from monolingual and bilingual environments', *Cognition*, 65(1), pp. 33-69.

Bosch, L. and Sebastián-Gallés, N. (2003) 'Simultaneous bilingualism and the perception of a language-specific vowel contrast in the first year of life', *Language and Speech,* 46(2-3), pp. 217-243.

Boysson-Bardies, B. D., Sagart, L. and Durand, C. (1984) 'Discernible differences in the babbling of infants according to target language', *Journal of Child Language*, 11(01), pp. 1-15.

Boysson-Bardies, B. d. and Vihman, M. M. (1991) 'Adaptation to language: Evidence from babbling and first words in four languages', *Language,* 67(2), pp. 297-319.

Brulard, I. and Carr, P. (2003) 'French-English bilingual acquisition of phonology: One production system or two?', *International Journal of Bilingualism*, 7(2), pp. 177-202.

Bullock, B. E. and Gerfen, C. (2004) 'Phonological convergence in a contracting language variety', *Bilingualism: Language and Cognition,* 7(2), pp. 95-104.

Burrows, L. and Goldstein, B. A. (2010) 'Whole word measures in bilingual children with speech sound disorders', *Clinical Linguistics & Phonetics,* 24(4-5), pp. 357-368.

Burton-Roberts, N., Carr, P. and Docherty, G. (2000) *Phonological Knowledge: Conceptual and Empirical Issues.* Oxford: Oxford University Press.

Bybee, J. (2001) *Phonology and Language Use.* Cambridge: Cambridge University Press.

Byers-Heinlein, K., Burns, T. C. and Werker, J. F. (2010) 'The roots of bilingualism in newborns', *Psychological Science,* 21(3), pp. 343-348.

Byers-Heinlein, K. and Fennell, C. T. (2014) 'Perceptual narrowing in the context of increased variation: Insights from bilingual infants', *Developmental Psychobiology,* 56(2), pp. 274-291.

Cameron, L. and Larsen-Freeman, D. (2007) 'Complex systems and applied linguistics', *International Journal of Applied Linguistics,* 17(2), pp. 226-240.

Campbell, T. F., Dollaghan, C. A., Rockette, H. E., Paradise, J. L., Feldman, H. M., Shriberg, L. D., Sabo, D. L. and Kurs-Lasky, M. (2003) 'Risk factors for speech delay of unknown origin in 3-year-old children', *Child Development,* 74(2), pp. 346-357.

Capirci, O., Iverson, J. M., Pizzuto, E. and Volterra, V. (1996) 'Gestures and words during the transition to two-word speech', *Journal of Child language,* 23(3), pp. 645-673.

Carson, C. P., Klee, T., Carson, D. K. and Hime, L. K. (2003) 'Phonological profiles of 2-year-olds with delayed language development: Predicting clinical outcomes at age 3', *American Journal of Speech-Language Pathology,* 12(1), pp. 28-39.

Cataño, L., Barlow, J. A. and Moyna, M. I. (2009) 'A retrospective study of phonetic inventory complexity in acquisition of Spanish: Implications for phonological universals', *Clinical Linguistics & Phonetics,* 23(6), pp. 446-472.

Chapman, K. L., Hardin-Jones, M., Schulte, J. and Halter Kelli, A. (2001) 'Vocal Development of 9-Month-Old Babies With Cleft Palate', *Journal of Speech, Language, and Hearing Research,* 44(6), pp. 1268-1283.

Chin, S. B. (2003) 'Children's consonant inventories after extended cochlear implant use', *Journal of Speech, Language, and Hearing Research,* 46(4), pp. 849-62.

Chomsky, N. (1987) *Generative Grammar: Its Basis, Development and Prospects.* Kyoto: Kyoto University of Foreign Studies.

Chomsky, N. and Halle, M. (1968) *The Sound Pattern of English.* Cambridge, MA: MIT Press.

Christophe, A., Gout, A., Peperkamp, S. and Morgan, J. (2003) 'Discovering words in the continuous speech stream: The role of prosody', *Journal of Phonetics,* 31(3-4), pp. 585-598.

Coupland, N. and Thomas, A. R. (1990) *English in Wales: Diversity, conflict, and change.* Clevedon: Multilingual Matters.

Curtin, S., Byers-Heinlein, K. and Werker, J. F. (2011) 'Bilingual beginnings as a lens for theory development: PRIMIR in focus', *Journal of Phonetics,* 39(4), pp. 492-504.

Davenport, M. and Hannahs, S. J. (2010) *Introducing Phonetics and Phonology.* 3rd edn. London: Hodder Education.

Davis, B. L. and MacNeilage, P. F. (1995) 'The Articulatory Basis of Babbling', *Journal of Speech, Language, and Hearing Research,* 38(6), pp. 1199-1211.

De Bot, K., Lowie, W. and Verspoor, M. (2007) 'A dynamic view as a complementary perspective', *Bilingualism: Language and Cognition,* 10(1), pp. 51-55.

De Houwer, A. (2007) 'Parental language input patterns and children's bilingual use', *Applied Psycholinguistics,* 28, pp. 411-424.

De Houwer, A. (2009) *Bilingual First Langauge Acquisition.* Bristol: Multilingual Matters.

DePaolis, R. A., Vihman, M. M. and Kunnari, S. (2008) 'Prosody in production at the onset of word use: A cross-linguistic study', *Journal of Phonetics,* 36(2), pp. 406-422.

Deuchar, M. (2005) 'Congruence and Welsh-English code-switching', *Bilingualism: Language and Cognition,* 8(3), pp. 255-269.

Dinnsen, D. A., Chin, S. B., Elbert, M. and Powell, T. W. (1990) 'Some constraints on functionally disordered phonologies: Phonetic inventories and phonotactics', *Journal of Speech, Language, and Hearing Research,* 33(1), pp. 28-37.

Dodd, B. (2013) *Differential Diagnosis and Treatment of Children with Speech Disorder.* Second edn. Chichester: John Wiley & Sons.

Dodd, B., Holm, A., Crosbie, S. and Hua, Z. (2005) 'Children's acquisition of phonology', in Dodd, B. (ed.) *Differential Diagnosis and Treatment of Children with Speech Disorder*. London: Whurr.

Dodd, B., Holm, A., Hua, Z. H. U. and Crosbie, S. (2003) 'Phonological development: a normative study of British English-speaking children', *Clinical Linguistics & Phonetics,* 17(8), pp. 617-643.

Dodd, B., Holm, A. and Wei, L. (1997) 'Speech disorder in preschool children exposed to Cantonese and English', *Clinical Linguistics & Phonetics,* 11(3), pp. 229-243.

Dodd, B. J., So, L. K. H. and Wei, L. (1996) 'Symptoms of disorder without impairment: The written and spoken errors of bilinguals', in Dodd, B., Campbell, R. and Worrall, L. (eds.) *Evaluating Theories of Language: Evidence from Disordered Communication*. London: Whurr, pp. 119-136.

Eadie, P., Morgan, A., Ukoumunne, O. C., Ttofari Eecen, K., Wake, M. and Reilly, S. (2015) 'Speech sound disorder at 4 years: prevalence, comorbidities, and predictors in a community cohort of children', *Developmental Medicine & Child Neurology,* 57(6), pp. 578-584.

Eimas, P. D., Siqueland, E. R., Jusczyk, P. and Vigorito, J. (1971) 'Speech perception in infants', *Science*, 171(3968), pp. 303-306.

Elbers, L. (1982) 'Operating principles in repetitive babbling: A cognitive continuity approach', *Cognition*, 12(1), pp. 45-63.

Ellis, N. C., O'Dochartaigh, C., Hicks, W., Morgan, M. and Laporte, N. (2001) 'Cronfa Electroneg o Gymraeg (CEG): A 1 million word lexical database and frequency count for Welsh. [On-line]', *https://www.bangor.ac.uk/canolfanbedwyr/ceg.php.en*.

Escudero, P. and Kalashnikova, M. (2020) 'Infants use phonetic detail in speech perception and word learning when detail is easy to perceive', *Journal of Experimental Child Psychology*, 190, pp. 104714.

Fabiano-Smith, L. and Barlow, J. A. (2010) 'Interaction in bilingual phonological acquisition: evidence from phonetic inventories', *International Journal of Bilingual Education and Bilingualism*, 13(1), pp. 81-97.

Fabiano-Smith, L. and Goldstein, B. A. (2010) 'Phonological acquisition in bilingual Spanish–English speaking children', *Journal of Speech, Language, and Hearing Research*, 53(1), pp. 160-178.

Fagan, M. K. (2009) 'Mean Length of Utterance before words and grammar: Longitudinal trends and developmental implications of infant vocalizations', *Journal of Child Language*, 36(3), pp. 495-527.

Fenson, L., Marchman, V., Thal, D., Dale, P., Reznick, J. and Bates, E. (2006) *MacArthur-Bates Communicative Development Inventories (CDI).* Second edn. Baltimore, MD: Brookes Publishing.

Ferguson, C. A. and Farwell, C. B. (1975) 'Words and sounds in early language', *Language*, 51(2), pp. 419-439.

Fernald, A. (2013) 'Relative language exposure, processing efficiency and vocabulary in Spanish–English bilingual toddlers', *Bilingualism: Language and Cognition*, 17(14).

Fikkert, P. (2006) 'Developing representations and the emergence of phonology: Evidence from perception and production', in Fougeron, C., Kuehnert, B., Imperio, M. and Vallee, N. (eds.) *Laboratory Phonology*. Berlin: De Gruyter, pp. 1-22.

Garmann, N. G., Hansen, P., Simonsen, H. G. and Kristoffersen, K. E. (2019) 'The phonology of children's early words: Trends, individual variation, and parents' accommodation in child-directed speech', *Frontiers in Communication*, 4, pp. 10.

Gathercole, V. C. M. and Thomas, E. M. (2009) 'Bilingual first-language development: Dominant language takeover, threatened minority language take-up', *Bilingualism: Language and Cognition,* 12(2), pp. 213-237.

Gathercole, V. C. M., Thomas, E. M. and Hughes, E. (2008) 'Designing a Normed Receptive Vocabulary Test for Bilingual Populations: A Model from Welsh', *International Journal of Bilingual Education and Bilingualism,* 11(6), pp. 678-720.

Genesee, F., Boivin, I. and Nicoladis, E. (1996) 'Talking with strangers: A study of bilingual children's communicative competence', *Applied psycholinguistics,* 17(4), pp. 427-442.

Gervain, J. and Werker, J. F. (2013) 'Prosody cues word order in 7-month-old bilingual infants', *Nature Communications,* 4(1), pp. 1-6.

Gildersleeve-Neumann, C. E., Kester, E. S., Davis, B. L. and Peña, E. D. (2008) 'English speech sound development in preschool-aged children from bilingual English-Spanish environments', *Language, Speech & Hearing Services in Schools,* 39(3), pp. 314-328.

Goldstein, B. A. and Bunta, F. (2012) 'Positive and negative transfer in the phonological systems of bilingual speakers', *International Journal of Bilingualism,* 16(4), pp. 388-401.

Goldstein, B. A., Bunta, F., Lange, J., Rodriguez, J. and Burrows, L. (2010) 'The effects of measures of language experience and language ability on segmental accuracy in bilingual children', *American Journal of Speech-Language Pathology*.

Goldstein, B. A., Fabiano, L. and Washington, P. S. (2005) 'Clinical forum. Phonological skills in predominantly English-speaking, predominantly Spanish-speaking, and Spanish-English bilingual children', *Language, Speech & Hearing Services in Schools,* 36(3), pp. 201.

Grech, H. and Dodd, B. (2008) 'Phonological acquisition in Malta: A bilingual language learning context', *International Journal of Bilingualism,* 12(3), pp. 155-171.

Green, J. R., Moore, C. A. and Reilly, K. J. (2002) 'The sequential development of jaw and lip control for speech', *Journal of Speech, Language, and Hearing Research,* 45(1), pp. 66-79.

Grosjean, F. (2001) 'The bilingual's language modes', in Nicol, J. (ed.) *One Mind, Two Languages: Bilingual Language Processing*. Oxford Blackwell, pp. 1-22.

Grosjean, F. and Byers-Heinlein, K. (2018) *The Listening Bilingual: Speech Perception, Comprehension, and Bilingualism.* Chichester: Wiley.

Grunwell, P. (1987) *Clinical Phonology.* London: Chapman and Hall.

Hambly, H., Wren, Y., McLeod, S. and Roulstone, S. (2013) 'The influence of bilingualism on speech production: A systematic review', *International Journal of Language & Communication Disorders,* 48(1), pp. 1-24.

Hannahs, S. J. (2013) *The Phonology of Welsh.* Oxford: Oxford University Press.

Harding-Bell, A. and Howard, S. (2011) 'Phonological approaches to speech difficulties associated with cleft palate', in Howard, S. and Lohmander, A. (eds.) *Cleft Lip and Palate: Assessment and Intervention*. Chichester: Wiley, pp. 275-292.

Hejná, M. (2015) *Pre-aspiration in Welsh English: A case study of Aberystwyth.* PhD dissertation, University of Manchester.

Hickey, T. M., Lewis, G. and Baker, C. (2014) 'How deep is your immersion? Policy and practice in Welsh-medium preschools with children from different language backgrounds', *International Journal of Bilingual Education and Bilingualism,* 17(2), pp. 215-234.

Hodges, R., Baker, E., Munro, N. and McGregor, K. K. (2017) 'Responses made by late talkers and typically developing toddlers during speech assessments', *International Journal of Speech-Language Pathology,* 19(6), pp. 587-600.

Holm, A., Crosbie, S. and Dodd, B. (2007) 'Differentiating normal variability from inconsistency in children's speech: normative data', *International Journal of Language & Communication Disorders,* 42(4), pp. 467-486.

Holm, A. and Dodd, B. (1999a) 'Differential diagnosis of phonological disorder in two bilingual children acquiring Italian and English', *Clinical Linguistics and Phonetics,* 13(2), pp. 113-129.

Holm, A. and Dodd, B. (1999b) 'A longitudinal study of the phonological development of two Cantonese-English bilingual children', *Applied Psycholinguistics,* 20, pp. 349-376.

Holm, A., Dodd, B., Stow, C. and Pert, S. (1999) 'Identification and differential diagnosis of phonological disorder in bilingual children', *Language Testing,* 16(3), pp. 271-292.

Hua, Z. and Dodd, B. (2006) 'A multilingual perspective on phonological development and disorders', in Hua, Z. and Dodd, B. (eds.) *Phonological development and disorders in children: A multilingual perspective*. Clevedon: Multilingual Matters, pp. 3-22.

Ingram, D. (2002) 'The measurement of whole-word productions', *Journal of Child Language,* 29(4), pp. 713.

Ingram, D. and Ingram, K. D. (2001) 'A whole-word approach to phonological analysis and intervention', *Language, Speech, and Hearing Services in Schools,* 32(4), pp. 271-283.

International Expert Panel on Multilingual Children's Speech (2012) *Multilingual children with speech sound disorders: Position paper.* Bathurst, NSW, Australia: Research Institute for Professional Practice, Learning and Education (RIPPLE), Charles Strut University. Available at: http://www.csu.edu.au/research/multilingual-speech/position-paper (Accessed: 18/07/2020.

Jakobson, R. (1968) *Child Language, Aphasia and Phonological Universals.* Paris: Mouton-The Hague.

James, D. G. (2001) 'Use of phonological processes in Australian children ages 2 to 7; 11 years', *Advances in Speech Language Pathology*, 3(2), pp. 109-127.

Joffe, V. and Pring, T. (2008) 'Children with phonological problems: a survey of clinical practice', *International Journal of Language & Communication Disorders,* 43(2), pp. 154-164.

Johnson, C. E. and Lancaster, P. (1998) 'The development of more than one phonology: A case study of a Norwegian-English bilingual child', *International Journal of Bilingualism,* 2(3), pp. 265-300.

Johnson, W. and Reimers, P. (2010) *Patterns in Child Phonology.* Edinburgh: Edinburgh University Press.

Jones, B. M. (1990) 'Welsh influence on children's English', in Coupland, N. and Thomas, A.R. (eds.) *English in Wales: Diversity, conflict, and change: Vol. 52*. Clevedon: Multilingual Matters, pp. 195-231.

Jones, G. E. (1984) 'The distinctive consonants and vowels of Welsh', in Ball, M.J. and Jones, G.E. (eds.) *Welsh Phonology: Selected Readings*. Cardiff: University of Wales Press, pp. 40-64.

Jusczyk, P. W. (1997) *The Discovery of Spoken Language.* Cambridge, MA: MIT Press.

Kager, R., Pater, J. and Zonneveld, W. (2004) *Constraints in Phonological Acquisition.* Cambridge University Press.

Karmiloff, K. and Karmiloff-Smith, A. (2009) *Pathways to Language: From Fetus to Adolescent.* Cambridge: Harvard University Press.

Kauschke, C. and Hofmeister, C. (2002) 'Early lexical development in German: A study on vocabulary growth and vocabulary composition during the second and third year of life', *Journal of Child Language,* 29(4), pp. 735-757.

Keffala, B., Scarpino, S., Hammer, C. S., Rodriguez, B., Lopez, L. and Goldstein, B. (2020) 'Vocabulary and phonological abilities affect dual language learners' consonant production accuracy within and across languages: A large-scale study of 3- to 6-year-old Spanish–

English dual language learners', *American Journal of Speech-Language Pathology*, 29(3), pp. 1196-1211.

Kehoe, M. (2015) 'Lexical-phonological interactions in bilingual children', *First Language*, 35(2), pp. 93-125.

Kehoe, M. and Havy, M. (2019) 'Bilingual phonological acquisition: the influence of language-internal, language-external, and lexical factors', *Journal of Child Language*, 46(2), pp. 292-333.

Keren-Portnoy, T., Majorano, M. and Vihman, M. M. (2009) 'From phonetics to phonology: The emergence of first words in Italian', *Journal of Child Language*, 36(02), pp. 235-267.

Kern, S., Davies, B. and Zink, I. (2009) 'From babbling to first words in four languages: Common trends across languages and individual differences', in D'Errico, F. and Hombert, J.M. (eds.) *Becoming Eloquent: Advances in the Emergence of Language, Human Cognition, and Modern Cultures*. Amsterdam: John Benjamins Publishing, pp. 205-232.

Khattab, G. (2002) '/l/ production in English-Arabic bilingual speakers', *International Journal of Bilingualism*, 6(3), pp. 335-353.

Khattab, G. (2013) 'Phonetic convergence and divergence strategies in English-Arabic bilingual children', *Linguistics*, 51(2), pp. 439-472.

Khattab, G. and Al-Tamimi, J. (2013) 'Influence of geminate structure on early Arabic templatic patterns', in Vihman, M.M. and Keren-Portnoy, T. (eds.) *The Emergence of Phonology: Whole-word Approaches and Cross-linguistic Evidence*. Cambridge: Cambridge University Press.

Khattab, G. and Roberts, J. (2011) 'Working with children', in Di Paolo, M. and Yaeger-Dror, M. (eds.) *Sociophonetics: a Student's Guide*. Oxon: Routledge, pp. 163-178.

Kim, N. and Davis, B. L. (2015) 'A phonetic approach to consonant repetition in early words', *Infant Behavior and Development*, 40, pp. 193-203.

Knight, D., Morris, S., Fitzpatrick, T., Rayson, P., Spasic, I., Thomas, E.-M., Lovell, A., Morris, J., Evas, J., Stonelake, M., Arman, L., Davies, J., Ezeani, I., Neale, S., Needs, J., Piao, S., Rees, M., Watkins, G., Williams, L., Muralidaran, V., Tovey, B., Anthony, L., Cobb, T., Deuchar, M., D'onelly, K., McCarthy, M. and Scannell, K. (2020) 'CorCenCC: Corpws Cenedlaethol Cymraeg Cyfoes - The National Corpus of Contemporary Welsh. [Digital Resource]', *www.corcencc.org/explore*.

Kohnert, K. (2013) *Language Disorders in Bilingual Children and Adults*. 2nd edn. San Diego, CA: Plural Publishing.

Kuhl, P. K. (2004) 'Early language acquisition: cracking the speech code', *Nature Reviews Neuroscience,* 5(11), pp. 831-843.

Kuhl, P. K., Conboy, B. T., Padden, D., Nelson, T. and Pruitt, J. (2005) 'Early speech perception and later language development: Implications for the "critical period"', *Language Learning and Development,* 1(3-4), pp. 237-264.

Kunnari, S. (2002) 'Word length in syllables: evidence from early word production in Finnish', *First language,* 22(2), pp. 119-135.

Kunnari, S., Nakai, S. and Vihman, M. M. (2001) 'Cross-linguistic evidence for the acquisition of geminates', *Psychology of Language and Communication,* 5(2), pp. 13-24.

Larsen-Freeman, D., Schmid, M. and Lowie, W. (2011) 'Introduction. From structure to chaos. Twenty years of modeling bilingualism', in Schmid, M. and Lowie, W. (eds.) *Modeling Bilingualism: From Structure to Chaos*. Amsterdam/Philadelphia: John Benjamins, pp. 1-11.

Leahy, J. and Dodd, B. (1987) 'The development of disordered phonology: A case study', *Language and Cognitive Processes,* 2(2), pp. 115-132.

Lee, C.-C., Jhang, Y., Chen, L.-M., Relyea, G. and Oller, D. K. (2017) 'Subtlety of ambient-language effects in babbling: A study of English- and Chinese-learning infants at 8, 10, and 12 months', *Language Learning and Development,* 13(1), pp. 100-126.

Lee, C.-C., Jhang, Y., Relyea, G., Chen, L.-m. and Oller, D. K. (2018) 'Babbling development as seen in canonical babbling ratios: A naturalistic evaluation of all-day recordings', *Infant Behavior and Development,* 50, pp. 140-153.

Lee, S. A. S., Davis, B. L. and MacNeilage, P. (2010) 'Universal production patterns and ambient language influences in babbling: A cross-linguistic study of Korean- and English-learning infants', *Journal of Child Language,* 37(02), pp. 293-318.

Leonard, L. B. (1992) 'Models of phonological development and children with phonological disorders', in Ferguson, C.A., Menn, L. and Stoel-Gammon, C. (eds.) *Phonological development: Models, Research, Implications*. Timonium, MD: York Press.

Lewedag, V. L., Oller, D. K. and Lynch, M. P. (1994) 'Infants' vocalization patterns across home and laboratory environments', *First Language,* 14(42-43), pp. 049-65.

Lindsay, S. and Gaskell, M. G. (2010) 'A complementary systems account of word learning in L1 and L2', *Language Learning,* 60, pp. 45-63.

Locke, J. L. (1989) 'Babbling and early speech: continuity and individual differences', *First Language,* 9(6), pp. 191-205.

Lust, B. C. (2006) *Child Language: Acquisition and Growth.* Cambridge University Press.

Macken, M. A. (1979) 'Developmental reorganization of phonology: A hierarchy of basic units of acquisition', *Lingua,* 49(1), pp. 11-49.

MacNeilage, P. F., Davis, B. L. and Matyear, C. L. (1997) 'Babbling and first words: Phonetic similarities and differences', *Speech Communication,* 22(2–3), pp. 269-277.

MacWhinney, B. (2005) 'A unified model of language acquisition', in Kroll, J.F. and De Groot, A.M.B. (eds.) *Handbook of Bilingualism: Psycholinguistic Approaches*. Oxford: Oxford University Press, pp. 49-67.

Maddieson, I. and Disner, S. F. (1984) *Patterns of Sounds.* Cambridge: Cambridge University Press.

Majorano, M. and D'Odorico, L. (2011) 'The transition into ambient language: A longitudinal study of babbling and first word production of Italian children', *First Language,* 31(1), pp. 47-66.

Matras, Y. (2020) *Language Contact.* Cambridge University Press.

Mayr, R., Howells, G. and Lewis, R. (2015) 'Asymmetries in phonological development: the case of word-final cluster acquisition in Welsh–English bilingual children', *Journal of Child Language,* 42(1), pp. 146-179.

Mayr, R., Jones, D. and Mennen, I. (2014) 'Speech learning in bilinguals: consonant cluster acquisition', in Thomas, E. and Mennen, I. (eds.) *Advances in the Study of Bilingualism*. Bristol: Multilingual Matters, pp. 3-24.

Mayr, R. and Montanari, S. (2015) 'Cross-linguistic interaction in trilingual phonological development: the role of the input in the acquisition of the voicing contrast', *Journal of Child Language,* 42(5), pp. 1006-1035.

Mayr, R., Morris, J., Mennen, I. and Williams, D. (2017) 'Disentangling the effects of long-term language contact and individual bilingualism: The case of monophthongs in Welsh and English', *International Journal of Bilingualism,* 21(3), pp. 245-267.

McClelland, J. L., McNaughton, B. L. and O'Reilly, R. C. (1995) 'Why there are complementary learning systems in the hippocampus and neocortex: insights from the successes and failures of connectionist models of learning and memory', *Psychological review,* 102(3), pp. 419.

McCormack, J., McLeod, S., Harrison, L. J. and McAllister, L. (2010) 'The impact of speech impairment in early childhood: Investigating parents' and speech-language pathologists' perspectives using the ICF-CY', *Journal of Communication Disorders,* 43(5), pp. 378-396.

McCune, L. (1992) 'First words: A dynamic systems view ', in Ferguson, C.A., Menn, L. and Stoel-Gammon, C. (eds.) *Phonological Development: Models, Research, Implications*: York Press.

McCune, L. and Vihman, M. M. (2001) 'Early phonetic and lexical development: A productivity approach', *Journal of Speech, Language, and Hearing Research,* 44(3), pp. 670-684.

McCune, L., Vihman, M. M., Roug-Hellichius, L., Delery, D. B. and Gogate, L. (1996) 'Grunt communication in human infants (Homo sapiens)', *Journal of Comparative Psychology,* 110(1), pp. 27-37.

McGillion, M., Herbert, J. S., Pine, J., Vihman, M., dePaolis, R., Keren-Portnoy, T. and Matthews, D. (2017) 'What paves the way to conventional language? The predictive value of babble, pointing, and socioeconomic status', *Child Development,* 88(1), pp. 156-166.

McIntosh, B. and Dodd, B. J. (2008) 'Two-year-olds' phonological acquisition: Normative data', *International Journal of Speech-Language Pathology,* 10(6), pp. 460-469.

McLeod, S., Daniel, G. and Barr, J. (2013) '"When he's around his brothers … he's not so quiet": The private and public worlds of school-aged children with speech sound disorder', *Journal of Communication Disorders,* 46(1), pp. 70-83.

Mees, I. M. and Collins, B. (1999) 'Cardiff: A real-time study of glottalisation', in Foulkes, P. and Docherty, G. (eds.) *Urban voices: Accent studies in the British Isles*. London: Routledge, pp. 185-202.

Mehler, J., Jusczyk, P., Lambertz, G., Halsted, N., Bertoncini, J. and Amiel-Tison, C. (1988) 'A precursor of language acquisition in young infants', *Cognition,* 29(2), pp. 143-178.

Mennen, I., Kelly, N., Mayr, R. and Morris, J. (2020) 'The effects of home language and bilingualism on the realization of lexical stress in Welsh and Welsh English', *Frontiers in Psychology,* 10.

Mitchell, P. R. and Kent, R. D. (1990) 'Phonetic variation in multisyllable babbling', *Journal of Child Language,* 17(02), pp. 247-265.

Molnar, M., Gervain, J. and Carreiras, M. (2014) 'Within-rhythm class native language discrimination abilities of Basque-Spanish monolingual and bilingual infants at 3.5 months of age', *Infancy,* 19(3), pp. 326-337.

Montanari, S., Subrahmanyam, K., Zepeda, M. and Rodriguez, C. (2014) 'The English phonological skills of latino Spanish-English dual-language preschoolers living in Los Angeles: Implications for practice', in Enrique-Arias, A., Gutierrez, M.J., Landa, A. and Ocampo, F. (eds.) *Perspectives in the Study of Spanish Language Variation*. Santiago de Compostela: Universidade de Santiago de Compostela.

Moon, C., Cooper, R. P. and Fifer, W. P. (1993) 'Two-day-olds prefer their native language', *Infant Behavior and Development,* 16(4), pp. 495-500.

Morgan, L. and Wren, Y. E. (2018) 'A systematic review of the literature on early vocalizations and babbling patterns in young children', *Communication Disorders Quarterly,* 40(1), pp. 3-14.

Morris, J. (2013) *Sociolinguistic variation and regional minority language bilingualism: an investigation of Welsh-English bilinguals in North Wales.* PhD dissertation, University of Manchester.

Morris, J. (2017) 'Sociophonetic variation in a long-term language contact situation: /l/-darkening in Welsh-English bilingual speech', *Journal of Sociolinguistics,* 21(2), pp. 183-207.

Morris, J. (2021) 'Social Influences on Phonological Transfer: /r/ Variation in the Repertoire of Welsh-English Bilinguals', *Languages,* 6(2), pp. 97.

Morris, J. and Hejná, M. (2020) 'Pre-aspiration in Bethesda Welsh: A sociophonetic analysis', *Journal of the International Phonetic Association,* 50(2), pp. 168-192.

Morris, J., Mayr, R. and Mennen, I. (2016) 'The role of linguistic background on sound variation in Welsh and Welsh English', in Durham, M. and Morris, J. (eds.) *Sociolinguistics in Wales*. London: Palgrave Macmillan, pp. 241-271.

Muldner, K., Hoiting, L., Sanger, L., Blumenfeld, L. and Toivonen, I. (2017) 'The phonetics of code-switched vowels', *International Journal of Bilingualism,* 23(1), pp. 37-52.

Munro, S., Ball, M. J., Müller, N., Duckworth, M. and Lyddy, F. (2005) 'Phonological acquisition in Welsh–English bilingual children', *Journal of Multilingual Communication Disorders,* 3(1), pp. 24-49.

Myers-Scotton, C. (2005) *Multiple Voices: An Introduction to Bilingualism.* Wiley.

Nathani, S., Ertmer, D. J. and Stark, R. E. (2006) 'Assessing vocal development in infants and toddlers', *Clinical Linguistics & Phonetics,* 20(5), pp. 351-369.

Newman, R. S., Rowe, M. L. and Ratner, N. B. (2016) 'Input and uptake at 7 months predicts toddler vocabulary: The role of child-directed speech and infant processing skills in language development', *Journal of Child Language,* 43(5), pp. 1158-1173.

Nip, I. S. B., Green, J. R. and Marx, D. B. (2009) 'Early speech motor development: Cognitive and linguistic considerations', *Journal of communication disorders,* 42(4), pp. 286-298.

Oller, D. K. and Eilers, R. E. (1982) 'Similarity of babbling in Spanish-and English-learning babies', *Journal of Child Language*, 9(3), pp. 565-577.

Oller, D. K., Eilers, R. E., Neal, A. R. and Schwartz, H. K. (1999) 'Precursors to speech in infancy: The prediction of speech and language disorders', *Journal of Communication Disorders*, 32(4), pp. 223-245.

Pancsofar, N. and Vernon-Feagans, L. (2006) 'Mother and father language input to young children: Contributions to later language development', *Journal of Applied Developmental Psychology*, 27(6), pp. 571-587.

Paradis, J. (2001) 'Do bilingual two-year-olds have separate phonological systems?', *International Journal of Bilingualism*, 5(1), pp. 19-38.

Paradis, J. (2007) 'Early bilingual and mulitilingual acquisition', in Auer, P. and Wei, L. (eds.) *Handbook of Multilingualism and Multilingual Communication*. Berlin: De Gruyter.

Paradis, J. and Genesee, F. (1996) 'Syntactic acquisition in bilingual children', *Studies in Second Language Acquisition*, 18(1), pp. 1-25.

Pearson, B. Z., Fernández, S. C. and Oller, D. K. (1993) 'Lexical development in bilingual infants and toddlers: Comparison to monolingual norms', *Language learning*, 43(1), pp. 93-120.

Penhallurick, R. (2004) 'Welsh English: Phonology', in Schneider, E.W., Burridge, K., Kortmann, B., Mesthrie, R. and Upton, C. (eds.) *A Handbook of the Varieties of English. Volume 1: Phonology*. New York: De Gruyter, pp. 98-112.

Penhallurick, R. (2008) 'Welsh English: Phonology', in Kortmann, B., Upton, C. and Schneider, E.W. (eds.) *Varieties of English. Vol 1: The British Isles*. London: Academic Press, pp. 105-121.

Pierrehumbert, J. B. (2001) 'Exemplar dynamics: Word frequency, lentition, and contrast', in Bybee, J. and Hopper, P. (eds.) *Frequency Effects and the Emergence of Lexical Structure*. Amsterdam: John Benjamins, pp. 137-157.

Pierrehumbert, J. B. (2003) 'Phonetic diversity, statistical learning, and acquisition of phonology', *Language and Speech*, 46(2-3), pp. 115-154.

Pinker, S. (2007) *The Language Instinct: How the Mind Creates Language.* New York: Harper.

Pinker, S. (2013) *Language, Cognition, and Human Nature: Selected Articles.* New York: Oxford University Press.

Poulin-Dubois, D. and Goodz, N. (2001) 'Language differentiation in bilingual infants: Evidence from babbling', in Cenoz, J. and Genesse, F. (eds.) *Trends in Bilingual Acquisition*. Amsterdam: John Benjamins, pp. 95-106.

Prezas, R. F., Hodson, B. W. and Schommer-Aikins, M. (2014) 'Phonological assessment and analysis of bilingual preschoolers' Spanish and English word productions', *American Journal of Speech-Language Pathology,* 23(2), pp. 176-185.

Quay, S. and Montanari, S. (2016) 'Early bilingualism: From differentiation to the impact of family language practices', in Montanari, S. and Nicoladis, E. (eds.) *Bilingualism Across the Lifespan: Factors Moderating Language Proficiency*. Berlin: Mouton de Gruyter, pp. 23-42.

Ramsdell-Hudock, H. L., Stuart, A. and Parham, D. F. (2018) 'Utterance duration as it relates to communicative variables in infant vocal development', *Journal of Speech, Language, and Hearing Research,* 61(2), pp. 246-256.

Robb, M. P. and Bleile, K. M. (1994) 'Consonant inventories of young children from 8 to 25 months', *Clinical Linguistics & Phonetics,* 8(4), pp. 295-320.

Rome-Flanders, T. and Cronk, C. (1995) 'A longitudinal study of infant vocalizations during mother–infant games', *Journal of Child Language,* 22(2), pp. 259-274.

Ruiz-Felter, R., Cooperson, S. J., Bedore, L. M. and Peña, E. D. (2016) 'Influence of current input–output and age of first exposure on phonological acquisition in early bilingual Spanish–English-speaking kindergarteners', *International Journal of Language & Communication Disorders,* 51(4), pp. 368-383.

Rvachew, S., Alhaidary, A., Mattock, K. and Polka, L. (2008) 'Emergence of the corner vowels in the babble produced by infants exposed to Canadian English or Canadian French', *Journal of Phonetics,* 36(4), pp. 564-577.

Rvachew, S., Mattock, K. and Polka, L. (2006) 'Developmental and cross-linguistic variation in the infant vowel space: The case of Canadian English and Canadian French', *Journal of the Acoustical Society of America,* 120(4), pp. 2250-2259.

Saffran, J. R., Aslin, R. N. and Newport, E. L. (1996) 'Statistical learning by 8-month-old infants', *Science,* 274(5294), pp. 1926-1928.

Sankoff, G. (2001) 'Linguistic outcomes of language contact', in Trudgill, P. and Schilling-Estes, N. (eds.) *Handbook of Sociolinguistics*. Oxford: Blackwell, pp. 638-668.

Sankoff, G. (2002) 'Linguistic outcomes of language contact', in Chambers, J.K., Trudgill, P. and Schilling-Estes, N. (eds.) *The Handbook of Language Variation and Change*. Oxford: Blackwell, pp. 644-674.

Scherer, N. J., Williams, L., Stoel-Gammon, C. and Kaiser, A. (2012) 'Assessment of single-word production for children under three years of age: Comparison of children with and without cleft palate', *International Journal of Otolaryngology,* 2012.

Sebastián-Gallés, N. and Bosch, L. (2009) 'Developmental shift in the discrimination of vowel contrasts in bilingual infants: is the distributional account all there is to it?', *Developmental Science,* 12(6), pp. 874-887.

Serkhane, J. E., Schwartz, J. L., Boë, L. J., Davis, B. L. and Matyear, C. L. (2007) 'Infants' vocalizations analyzed with an articulatory model: A preliminary report', *Journal of Phonetics,* 35(3), pp. 321-340.

Shriberg, L. D., Austin, D., Lewis, B. A., McSweeny, J. L. and Wilson, D. L. (1997) 'The percentage of consonants correct (PCC) metric: extensions and reliability data', *Journal of Speech, Language & Hearing Research,* 40(4), pp. 708-722.

Shriberg, L. D., Fourakis, M., Hall, S. D., Karlsson, H. B., Lohmeier, H. L., McSweeny, J. L., Potter, N. L., Scheer-Cohen, A. R., Strand, E. A., Tilkens, C. M. and Wilson, D. L. (2010) 'Extensions to the speech disorders classification system (SDCS)', *Clinical Linguistics & Phonetics,* 24(10), pp. 795-824.

Smith, B. L., Brown-Sweeney, S. and Stoel-Gammon, C. (1989) 'A quantitative analysis of reduplicated and variegated babbling', *First Language,* 9(6), pp. 175-189.

Sosa, A. V. and Stoel-Gammon, C. (2006) 'Patterns of intra-word phonological variability during the second year of life', *Journal of Child Language,* 33(1), pp. 31.

Sosa, A. V. and Stoel-Gammon, C. (2012) 'Lexical and phonological effects in early word production', *Journal of Speech, Language, and Hearing Research*.

Stackhouse, J. and Wells, B. (1997) *Children's Speech and Literacy Difficulties: A Psycholinguistic Framework.* London: Singular Publishing Group.

Stoel-Gammon, C. (1985) 'Phonetic inventories, 15-24 Months: A longitudinal study', *Journal of Speech and Hearing Research,* 28(4), pp. 505-512.

Stoel-Gammon, C. (1987) 'Phonological skills of 2-Year-olds', *Language, Speech & Hearing Services in Schools,* 18, pp. 323-329.

Stoel-Gammon, C. (2011) 'Relationships between lexical and phonological development in young children', *Journal of Child Language,* 38(1), pp. 1-34.

Stokes, S. F. and Klee, T. (2009) 'The diagnostic accuracy of a new test of early nonword repetition for differentiating late talking and typically developing children', *Journal of Speech, Language & Hearing Research,* 52(4), pp. 872-882.

Thelen, E. and Smith, L. B. (1996) *A Dynamic Systems Approach to the Development of Cognition and Action.* Cambridge, MA: MIT Press.

Thomas, A. R. (1994) 'English in Wales', in Burchfield, R. (ed.) *The Cambridge History of the English Language. Volume V - English in Britain and Overseas: Origins and Development*. Cambridge: Cambridge University Press, pp. 94-147.

Tomasello, M. (2003) *Constructing a Language: A Usage-Based Theory of Language Acquisition.* Boston: Harvard University Press.

Van Severen, L., Van Den Berg, R., Molemans, I. and Gillis, S. (2012) 'Consonant inventories in the spontaneous speech of young children: A bootstrapping procedure', *Clinical Linguistics & Phonetics,* 26(2), pp. 164-187.

Velleman, S. L. and Vihman, M. M. (2002) 'Whole-word phonology and templates: Trap, bootstrap, or some of each?', *Language, Speech Hearing Services in Schools,* 33(1), pp. 9-23.

Velleman, S. L. and Vihman, M. M. (2006) 'Phonology development in infancy and early childhood: implications for theories of language learning', in Pennington, M.C. (ed.) *Phonology in Context*. Luton: Macmillan, pp. 25-50.

Vihman, M. (2016) 'Prosodic structures and templates in bilingual phonological development', *Bilingualism: Language and Cognition,* 19(1), pp. 69-88.

Vihman, M. and Majorano, M. (2017) 'The role of geminates in infants' early word production and word-form recognition', *Journal of Child Language,* 44(1), pp. 158-184.

Vihman, M. M. (1993) 'Variable paths to early word production', *Journal of Phonetics,* 21(1-2), pp. 61-82.

Vihman, M. M. (2000) *Prosodic development: A cross-linguistic analysis of the first word period.*, End of award report, Economic and Social Research Council Award R000237087, January.

Vihman, M. M. (2002) 'Getting started without a system: From phonetics to phonology in bilingual development', *International Journal of Bilingualism,* 6(3), pp. 239-254.

Vihman, M. M. (2009) 'Word learing and the origins of phonological systems', in Foster-Cohen, S.H. (ed.) *Language Acquisition*. Luton: Palgrave Macmillan.

Vihman, M. M. (2010) 'Phonological templates in early words', in Fougeron, C., Kuehnert, B., Imperio, M. and Vallee, N. (eds.) *Laboratory Phonology 10*. Berlin: De Gruyter.

Vihman, M. M. (2014) *Phonological Development: The First Two Years.* Oxford: Wiley.

Vihman, M. M. (2017) 'Learning words and learning sounds: Advances in language development', *British Journal of Psychology,* 108(1), pp. 1-27.

Vihman, M. M. and Croft, W. (2007) 'Phonological development: toward a "radical" templatic phonology', *Linguistics,* 45(4), pp. 683-725.

Vihman, M. M. and de Boysson-Bardies, B. (1994) 'The Nature and Origins of Ambient Language Influence on Infant Vocal Production and Early Words', *Phonetica,* 51(1-3), pp. 159-169.

Vihman, M. M., Ferguson, C. A. and Elbert, M. (1986) 'Phonological development from babbling to speech: Common tendencies and individual differences', *Applied Psycholinguistics,* 7(01), pp. 3-40.

Vihman, M. M. and Keren-Portnoy, T. (2013) *The Emergence of Phonology: Whole-word Approaches and Cross-linguistic Evidence.* Cambridge: Cambridge University Press.

Vihman, M. M. and Kunnari, S. (2006) 'The sources of phonological knowledge: A cross-linguistic perspective', *Recherches linguistiques de Vincennes,* (35), pp. 133-164.

Vihman, M. M., Macken, M. A., Miller, R., Simmons, H. and Miller, J. (1985) 'From babbling to speech: A re-assessment of the continuity issue', *Language,* 61(2), pp. 397-445.

Vihman, M. M. and McCune, L. (1994) 'When is a word a word?', *Journal of Child Language,* 21(03), pp. 517-542.

Vihman, M. M. and Velleman, S. L. (1989) 'Phonological Reorganization: A Case Study', *Language and Speech,* 32(2), pp. 149-170.

Vihman, M. M. and Velleman, S. L. (2000) 'The construction of a first phonology', *Phonetica,* 57(2-4), pp. 255-266.

Volterra, V. and Taeschner, T. (1978) 'The acquisition and development of language by bilingual children', *Journal of Child Language,* 5(02), pp. 311-326.

Vorperian, H. K., Kent, R. D., Lindstrom, M. J., Kalina, C. M., Gentry, L. R. and Yandell, B. S. (2005) 'Development of vocal tract length during early childhood: A magnetic resonance imaging study', *The Journal of the Acoustical Society of America,* 117(1), pp. 338-350.

Waring, R. and Knight, R. (2013) 'How should children with speech sound disorders be classified? A review and critical evaluation of current classification systems', *International Journal of Language & Communication Disorders,* 48(1), pp. 25-40.

Waterson, N. (1971) 'Child phonology: A prosodic view', *Journal of Linguistics,* 7(2), pp. 179-211.

Webb, K. 'The realisation of stress in Welsh English'. *17th International Congress of Phonetic Sciences*, Hong Kong Convention and Exhibition Centre, Hong Kong, 2106-2109.

Wells, J. C. (1982) *Accents of English: Volume 2.* Cambridge: Cambridge University Press.

Welsh Government (2021) *Welsh language data from the Annual Population Survey: July 2020 to June 2021*. Welsh language data from the Annual Population Survey. Available at: https://gov.wales/welsh-language-data-annual-population-survey-july-2020-june-2021.

Werker, J. F. (1994) 'Cross-language speech perception: Development change does not involve loss', in Goodman, J. and Nusbaum, H. (eds.) *The Development of Speech Perception: The Transition from Speech Sounds to Spoken Words*. Cambridge, MA: MIT Press, pp. 93-120.

Werker, J. F. and Pegg, J. E. (1992) 'Infant Speech Perception and Phonological Acquisition', in Ferguson, C.A., Menn, L. and Stoel-Gammon, C. (eds.) *Phonological Development: Models, Research and Implications*. Timonium, MD: York Press, pp. 285-311.

Werker, J. F. and Tees, R. C. (1984) 'Cross-language speech perception: Evidence for perceptual reorganization during the first year of life', *Infant Behavior and Development,* 7(1), pp. 49-63.

Werker, J. F. and Yeung, H. H. (2005) 'Infant speech perception bootstraps word learning', *Trends in Cognitive Sciences,* 9(11), pp. 519-527.

Williams, A. L. and Elbert, M. (2003) 'A prospective longitudinal study of phonological development in late talkers', *Language, Speech & Hearing Services in Schools,* 34(2), pp. 138.

Williams, B. (1983) *Stress in modern Welsh.* PhD thesis, University of Cambridge.

Williams, B. (1985) 'Pitch and duration in Welsh stress perception: the implications for intonation', *Journal of Phonetics,* 13(4), pp. 381-406.

Williams, B. (1999) *The Phonetic Manifestation of Stress in Welsh.* Berlin: Mouton de Gruyter.

Williams, N. and Chiat, S. (1993) 'Processing deficits in children with phonological disorder and delay: a comparison of responses to a series of output tasks', *Clinical linguistics & phonetics,* 7(2), pp. 145-159.

Wren, Y., Miller, L. L., Peters, T. J., Emond, A. and Roulstone, S. (2016) 'Prevalence and predictors of persistent speech sound disorder at eight years old: Findings from a population cohort study', *Journal of Speech, Language, and Hearing Research,* 59(4), pp. 647-673.

Yavaş, M. and Marecka, M. (2014) 'Acquisition of Polish #sC clusters in typically-developing children and children with phonological disorders', *International Journal of Speech-Language Pathology,* 16(2), pp. 132-141.

Yeni-Komshian, G. H., Flege, J. E. and Liu, S. (2000) 'Pronunciation proficiency in the first and second languages of Korean–English bilinguals', *Bilingualism: Language and Cognition,* 3(2), pp. 131-149.

Appendix A (Chapter 3)

Appendix A1 - Detailed language input information

Beca

	2011						2012									
	Jun	Jul	Aug	Sep	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Mo	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M
Tu	F	F	F	F	F	F	F	F	M	M	M	M	M	M	M	M
We	M	M	M	M	M	M	M	M	F	F	F	F	F	F	F	F
Th	G	G	G	G	G	G	F	F	F	F	F	F	F	F	F	F
Fr	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Sat + Sun	M+F	M+F	M+F	M+F	M+F	M+F	M+F	M+F	M+F	M+F	M+F	M+F	M+F	M+F	M+F	M+F

M: Mother F: Father N: Nursery G: Grandmother

Welsh English Welsh and English

Ben

	2011						2012									
	Jun	Jul	Aug	Sep	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Mon	F	F	F	M	M	M	M	M	M	M	M	M	M	M	M	M
Tue	F	F	F	M	M	M	M	M	M	M	M	M	M	M	M	M
Wed	F	F	F	M	M	M	M	M	M	M	M	M	M	M	M	M
Thu	F	F	F	M	M	M	M	M	M	M	M	M	M	M	M	M
Fri	F	F	F	M	M	M	M	M	M	M	M	M	M	M	M	M
Sat + Sun	M+F	M+F	M+F	M+F	M+F	M+F	M+F	M+F	M+F	M+F	M+F	M+F	M+F	M+F	M+F	M+F

M: Mother F: Father

Welsh English Welsh and English

Gwen

	2011				2012											
	Aug	Sep	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mon-Fri	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M
Sat + Sun	M+F	M+F	M+F	M+F	M+F	M+F	M+F	M+F	M+F	M+F	M+F	M+F	M+F	M+F	M+F	M+F

M: Mother F: Father Welsh

Gwawr

	2011						2012									
	Jun	Jul	Aug	Sep	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Mon-Wed	C	C	C	N	N	N	N	N	N	N	N	N	N	N	N	N
Thu	M	M	M	N	N	N	N	N	N	N	N	N	N	N	N	N
Fri	M	M	M	M	M	M	M	M	M	M	M	M	M	M	N	N
Sat + Sun	M+F	M+F	M+F	M+F	M+F	M+F	M+F	M+F	M+F	M+F	M+F	M+F	M+F	M+F	M+F	M+F

M: Mother F: Father N: Nursery C: Childminder Welsh

Ed

	2011						2012									
	Jun	Jul	Aug	Sep	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Mon-Sun	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M

M: Mother English

Eve

	2012											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mon	M	M	M	M	M	M	M	M	M	M	M	M
Tues	N	N	N	N	N	N	N	N	N	N	N	N
Wed-Fri	M	M	M	M	M	M	M	M	M	M	M	M
Sat + Sun	M+F	M+F	M+F	M+F	M+F	M+F	M+F	M+F	M+F	M+F	M+F	M+F

M: Mother F: Father N: Nursery
English Welsh

Appendix A2 – Schedule of sessions recorded and analysed

Table depicting each data collection session and each child's age (in years;months;days). Sessions that were scheduled but data collection was not possible due to illness or lack of availability are depicted by the cells shaded in grey. The sessions that were analysed in detail are marked in **bold.**

	Gwawr	Gwen	Ed	Eve	Ben		Beca	
					Welsh	English	Welsh	English
1;1	**1;1;7**	**1;1;6**						
1;2			**1;2;17**	**1;1;21**			**1;2;1**	**1;2;4**
1;3	**1;3;1**	**1;2;27**		**1;3;1**	1;2;25	1;2;25		
1;4	**1;4;13**	**1;4;7**	**1;3;29**		**1;4;17**	**1;4;10**	**1;3;20**	**1;3;25**
1;5			**1;5;17**	**1;4;28**				
1;6	**1;6;1**	1;6;15			1;5;28	1;5;29	**1;5;19**	**1;5;19**
1;7				**1;7;3**			1;7;14	1;7;15
1;8	1;8;10		**1;8;0**		**1;8;9**	**1;8;6**		
1;9			**1;9;11**	**1;8;21**			**1;9;9**	**1;9;9**
1;10	1;9;22	1;9;22		**1;9;21**	1;9;18	1;9;20		
1;11	1;11;17	1;11;17	1;11;0	1;11;3	1;11;13	1;11;9	1;10;20*	1;10;20*
2;0	2;0;12		2;0;26	2;0;17				
2;1					**2;1;11**	**2;1;8**	2;1;8	2;1;8
2;2	2;2;17	2;2;13						
2;3								
2;4	2;4;13	2;3;27			2;4;5	2;4;0		
2;5	2;5;17						2;5;10	2;5;10
2;6					**2;5;16**	**2;5;19**	2;6;15	

*Vocalisations identified and transcribed but not included in final analysis as 25-word point had been reached during previous session (1;9;9)

Appendix B (Chapter 4)

Appendix B1 – Word lists

Type A word lists for each session – Welsh environment

Beca

1;2;1
haia *(hyia)*-23
helo *(hello)*-5
wow wow *(woof woof)*-1
na *(no)*-3
ia *(yes)*-3

1;3;21
haia *(hyia)*-33
ia *(yes)*-16
hwnna *(that one)*-3
na *(no)*-3
iei *(yay)*-3
da *(tah)*-3
uh-oh-2
ceffyl *(horse)*-1
buwch *(cow)*-1
tarw *(bull*-1
wow wow *(woof woof)*-1
a fi *(and me)*-1
tedi *(teddy)*-1
dau *(two)*-1
sgidie *(shoes)*-1
agor *(open)*-1
eto *(again)*-1
cacen *(cake)*-1
dada *(dadda)*-1
na ni *(there we go)*-1
banana *(banana)*-1

1;5;19
ia *(yes)*-10
helo *(hello)*-6
ceffyl *(horse)*-4
dau *(dau)*-4
bzz-3
ci *(dog)*-3
iei *(yey)*-3
ah-2
oh!-2
uh-oh-2
bwni *(bunny)*-1
dacw hi *(there she is)*-2
haia *(hiya)*-1
mochyn *(pig)*-1
sh!-1
tedi *(teddy)*-1
un *(one)*-1
wi *(wee)*-1

1;9;9
uh-oh-50
bib bib *(beep beep)*-23
ia *(yes)*-35
na *(no)*-18
oh-16
hello-6
yli *(look)*-6
dear-5
baby-5
banana-3
cath *(cat)*-3
dau *(two)*-3
oh dear-3
pw *(poo)*-3
sori *(sorry)*-3
there we go-3
cwac cwac *(quack quack)*-3
aw *(ouch)*-3
go-3
bi-bo *(peep-po)*-2
ci *(dog)*-2
du *(black)*-2
haia *(hiya)*-2
oh-2
oh no-2
juice-2
tedi *(teddy)*-1
teli *(telly)*-1
ych *(yuk)*-1
bath-1
boots-1
caws *(cheese)*-1
chair-1
coed *(trees)*-1
dro *(a walk)*-1
fi *(me)*-1
gai o *(leave it)*-1
good-1
goriadau *(keys)*-1
hair-1
here we go-1
hey-1
lets go-1
mami *(mammy)*-1
more-1
nol *(back)*-1
oren *(orange)*-1
stay there-1
torri *(break)*-1
tri *(three)*-1
here

Ben

1;4;17
ia *(yes)*-7
da *(tah)*-1

1;8;09
na *(no)*-39
ta ta *(bye bye)*-23
ia *(yes)*-10
wow-5
da *(tah)*-4
bi-bo *(peep-po)*-3
oh-3
a! *(ah)*-3
yeah-2
a parrot-1
ah-ha-1
fana *(there)*-1
more-1
oh-oh-1

2;1;09
ia *(yes)*-114
na *(no)*-67
ah-ha-22
tah-dah-8
mwy *(more)*-6
bye bye-5
wee-5
aw *(ouch)*-7
back-3
haia *(hiya)*-3
ach *(yuk)*-1
dad-1
hm-1
mam-1
ym *(erm)*-1

2;5;16
mam *(mum)*-95
ia *(yes)*-75
na *(no)*-30
o na *(oh no)*-7
a mwy *(and more)*-7
ow *(oh)*-5
bib *(beep)*-4
hm-4
ah-ha-4
aw *(ouch)*-4
ym *(erm)*-4
sana *(socks)*-3
lawr *(down)*-3
ach *(yuk)*-2
o (disappointment)-2
o wel *(oh well)*-2
thank you-1
blue-1
gola *(light)*-1
dau *(two)*-1
haia *(hiya)*-1
tah-da-1
oce *(okay)*-1

Gwen

1;1;6

mam *(mum)*-4
dau *(two)*-3
bw *(boo)*-2
go-2
cwac *(quack)*-2
ia *(yes)*-1
peppa-1
uh-oh-1
chwadan *(duck)*-1
ow *(oh)*-1

1;2;27

dau *(two)*-20
da *(tah)*-10
ma'n iawn *(it's alright)*-8
ow *(oh)*-7
iei *(yay)*-5
ia *(yes)*-5
dad-4
diolch *(thank you)*-6
cwac cwac *(quac quack)*-4
na *(no)*-3
stretch bach *(little stretch)*-3
a mwy *(and more)*-2
uh-oh-2
mam *(mum)*-2
na fo *(that's it)*-2
ta ta *(bye bye)*-2
bont *(bridge)*-1
bron iawn *(nearly)*-1
olwyn *(wheel)*-1
hufen ia *(ice cream)*-1
Cadi-1
no-1
paid *(don't)*-1
wff*(ooph)*-1
wei *(variant of yay)*-1

1;4;7

mam *(mum)*-17
ow *(oh)* -16
na *(no)*-2
pel *(ball)*-11
peppa-10
cloc *(clock-)*8
ia *(yes-)*8
nain *(grandmother)*-8
ta ta *(goodbye)*-6
dim twtsad *(don't touch)*-5
bib bib *(beep beep)*-3
dau *(two)*-3
haia *(hiya)*-3
llew *(lion)*-3
hello-3
da *(tah)*-2
golau *(light)*-2
ci *(dog-)*2
cwch *(boat)*-2
ma'n iawn *(it's alright)*-2
mw *(moo-)*2
Noni-2
splish splash splosh-2
ted-2
cwac cwac *(quack quack)*-2
hwnna *(that one)*-1
miaw-1
uh-oh-1
da de *(good one)*-1
George1
doli glwt *(rag doll)*-1
oh no-1
fish-1
gad o *(leave it)*-1
gad hwna fod *(leave it be)*-1
go-1
glaw *(rain)*-1
het *(hat)*-1
iei *(yay)*-1
coch *(red)*-1
cwtch *(hug)*-1
lle mae o *(where is it*)-1
Maggy-1
Mowgli a balw *(mogli and baloo)*-1
pedwar *(four)*-1
pump *(five)*-1
see you soon-1
slo bach *(slow)*-1
ti'n iawn *(are you alright)*-1
un o'gloch *(one o'clock)*-1
oh no-1
oops-1
dad-1

Gwawr

1;1;7
da *(tah)*-13
haia *(hiya)*-6
ta ta *(bye bye)*-1

1;3;1
ta ta *(bye bye)*-2
haia *(hiya)*-1
Begw-1
wpadeis *(oops a daisy)*-1
na *(no)*-1
bang-1
pi-po *(pee-po)*-1
do *(yes)*-1
camra *(camera)-1*
miaw-1

1;4;13
mam *(mum)*-12
dad-7
na *(no)*-6
iei *(yay)*-5
da *(tah)*-4
clwt *(nappy)*-3
dau *(two)*-2
nain *(granny)*-2
tedi *(teddy)*-2
me *(baa)*-1
agor *(open)*-1
coch *(red)*-1
doli *(dolly)*-1
fama *(here)*-1
hello-1
ho ho ho-1
sh-1
taid *(grandad)*-1
yli *(look)*-1

1;6;1
mam *(mum)*-21
babi *(baby)*-11
na *(no)*-9
ia *(yes)*-5
uh-oh-5
dad-4
ha-4
iei *(yay)*-4
Begw-3
gog gog (iar) *(chicken)*-3
ho ho ho-3
tedi *(teddy)*-3
this-3
cwac *(quack)*-2
cwch *(boat)*-2
nain *(granny)*-2
oh-2
ta *(tah)*-2
ta ta *(bye bye)*-2
ooh ooh ooh-1
beic *(bike)*-1
brwsh *(brush)*-1
car *(car)*-1
gwdihw *(owl)*-1
me *(baa)*-1

Type B Word lists for each session: Welsh environment

Beca

1;9;9
‘counting’-6
‘spelling’-5
‘train noise’-2
‘train whistle sound’-2
‘eating noise’-1

Ben

1;4;17
‘train noise’-4

1;8;09
‘engine noise’-1

2;1;09
‘train protoword’-50
‘counting’-23
‘snoring’-23
‘eating noise’-11
‘sleeping’-3
‘train noise’-3
‘shooting noise’-2

2;5;16
‘eating noise’-4
‘snoring’-4
‘humming’-3
‘plane noise’-1
‘train protoword’-1

Gwen

1;2;27
‘train whistle sound’-1

1;4;7
‘pig snort’-2
‘fish noise’-8
‘train whistle sound’-1

Gwawr

1;3;1
‘kiss’-6
‘lion noise’-2
‘train whistle sound’-1

1;4;13
‘counting’-10
‘lion noise’-2

1;6;1
‘train whistle sound’-9
‘lion noise’-4
‘car noise’-3
‘pig noise’-1
‘fish noise’-1

Type A word list for each session – English environment

Beca

1;2;4
hiya-14
hello-2
baby-2
dad-2
bowl-1

1;3;25
yes-5
hiya-4
da *(tah)*-3
uh-oh-2
hello-2
yum-2
no-2
yuk-1
oh dear-1
gone-1
horse-1
yay-1
moo-1
ta ta (*bye bye)*-1

1;5;19
yes-22
there we are-9
uh-oh-6
hello-4
ahhh-2
what's this-2
yuk-1
fish-1
go-1
hiya-1
milk-1
oh yeah-1
this-1
yey-1
goody-1

1;9;9
yes-33
gone-26
uh-oh-22
baby-9
there we go-8
oh-8
poo-5
hiya-4
thank you-3
Annie-3
hello-3
oh dear-3
mmm-2
oo! gone-2
weee-2
yay-2
all gone-1
found you-1
hang on-1
here you are-1
hey-1
man iawn *it's alright)*-1
mine-1
more-1
no way-1
owff *(ooph)*-1
sit there-1
sorry-1
there-1
eww-1

Ben

1;8;06

no-39
yes-33
daddy-13
ta ta *(bye bye)*-12
hm-5
more-4
hiya-3
ah-ha-1
all gone-1
bi-*bo (pee-po)-1*
who is it?-1
who's that?-1

2;1;08

yes-168
no-16
ta ta-11
hm-10
erm-6
oh dear-4
bye bye-3
dad-3
err-3
ach *(yuk)*-2
poo-2
tah-dah-2
oh-2
hiya-1
more-1
wow-1
well-1
ah-ha-1

2;5;19

yes-64
dad-50
na-33
more-12
oh-11
lawr-7
mam-4
da-3
hm-3
okay-3
hiya-2
ah-ha-2
m-hm-2
o wel-2
ach *(yuk)*-1
bag-1
erm-1
all gone-1
poo-1
wow-1
aw *(ouch)*-1

Eve

1;1;21
yes-2
ta-2
again-1
heya-1
don't know-1
take it off-1
toe-1

1;3;1
daddy-6
yes-3
t is-1
goes there-1
ha-1
Mm-1

1;4;28
egg-34
dadda-4
peg-1
press it-1
chick chick-1
what's that-1
what's this-1
oh dear-1

1;7;3
shoes-18
na-9
tigger-6
book-6
do that-3
toots-3
yeah-3
down there-1
hiya-1
it's there-1
oh na-1
push-1
red-1
whats that?-1

1;8;21
Bella-14
book-10
duck-9
mam-5
oh no-4
egg-3
na-3
shoes-3
daddy-2
ball-1
better-1
chick chick-1
fish-1
gone-1
poop-1
purple-1
yeah-1
yellow-1
another-1

1;9;21
dog-5
bella-4
bucket-4
na-4
basket-3
boy-3
duck-3
fish-3
moo-3
pig-3
tortoise-3
tractor-3
door-3
frog-3
shoe-3
bag-2
bear-2
chick-2
deer-2
egg-2
horse-2
house-2
naughty-2
no-2
rabbit-2
truck-2
who's that-2
yuk-2
there-2
baa-1
bee-1
bird-1
biscuit-1
boat-1
car-1
daddy-1
dolphin-1
flower-1
fox-1
goat-1
kangaroo-1
monkey-1
mouse-1
oh-1
owl-1
panda-1
purple-1
push that-1
quack
quack-1
shark-1
sheep-1
snail-1
that's it-1
this-1
tiger-1
two feet-1
snake-1

woof woof-1
pink-1
that-1
book-1

Ed

1;2;17
ta-14
no-3
hiya-3

1;3;19
mum-10
hiya-7
sit-4
bye bye-2
yeah-2
oh yeah-1
ta ta-1
I see it-1
uh-oh-1
book-1

1;5;17
no-16
more-8
mum-3
yes-2
bye bye-1
crash-1
go-1
hello-1
hiya-1
phone-1
there-1

1;8;0
mummy-6
wei-5
uh oh-2
up-2
wow-2
gruffalo-1
moo-1
no-1
that's ok-1
there-1
this-1
this one-1

1;9;11
oh no-7
tractor-7
more-5
na-3
ouch-3
uh-oh-3
yes/yeah-2
flower-2
o na-2
oh-2
rabbit-2
there-2
snake-1
boo-1
for you-1
gone-1
here-1
house-1
out-1
this-1
twinkle twinkle-1
what's that-1
cow-1
chair-1
tea-1
knife-1
car-1
done it-1

Type B word list for each session – English environment

Beca

1;3;25
‘lion noise’-1

1;5;19
‘pouring sound’-2
‘drinking sound’-1

1;9;9
‘counting’-55

Ben

2;1;08
‘train protoword’-72
‘eating noise’-5
‘snoring’-2

2;5;19
‘train protoword’-12
‘reversing beep beep’-1

Eve

1;7;3
‘kissing’-6
‘horse noise’-1

Ed

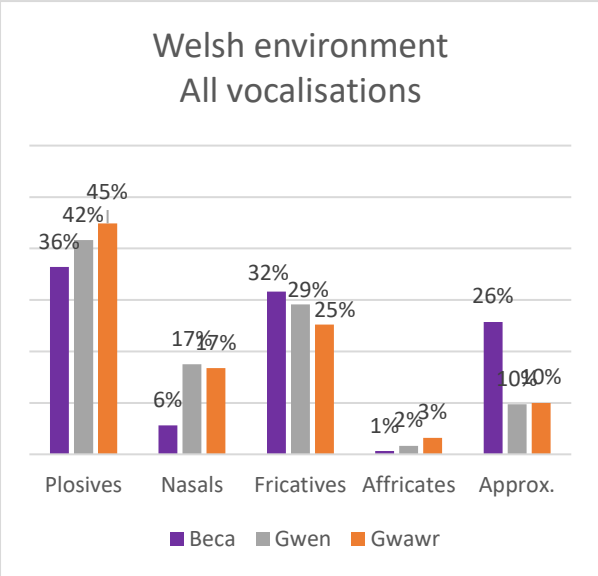
1;3;29
‘lion noise’-5
‘dog noise’-1

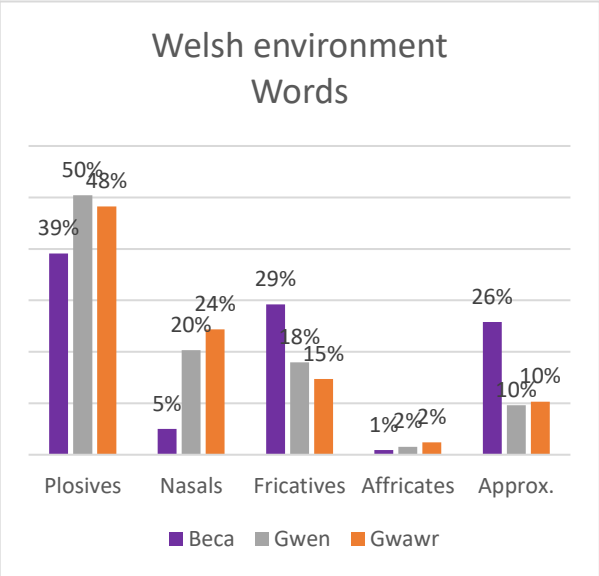
1;5;17
‘car engine noise’-6-
‘snoring’-1

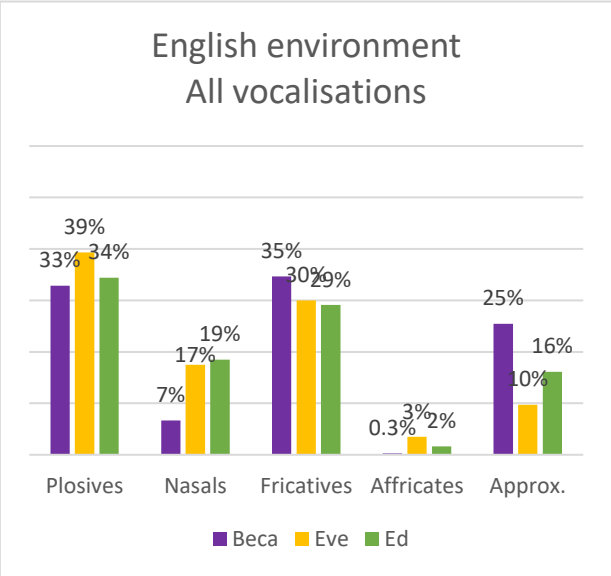
1;8;0
‘hoover noise’-9
‘counting’-7
‘train noise’-4
‘animal noise’-3
‘bell ringing’-1
‘car engine noise’-1-
‘snake hiss’-1

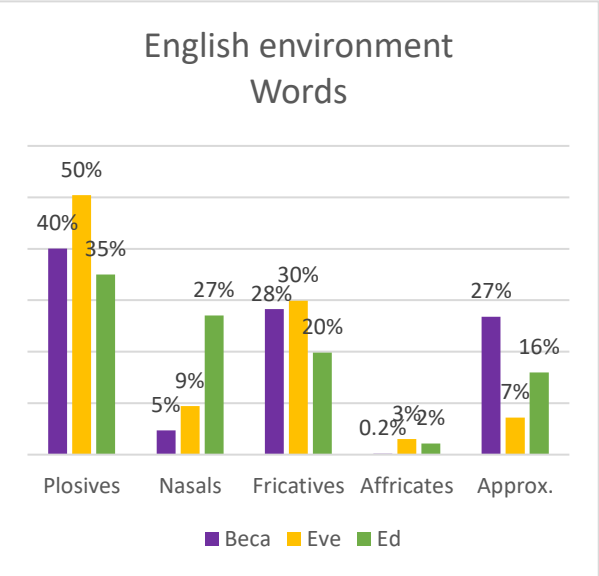
1;9;11
‘snake hiss’-5
‘car engine noise’-3
‘bounce bounce’-2
‘elephant noise’-2
‘fish noise’-1
‘sheep noise’-1-
‘lion noise'-1

Appendix B2 - Occurrence of manner of articulation categories for individual children

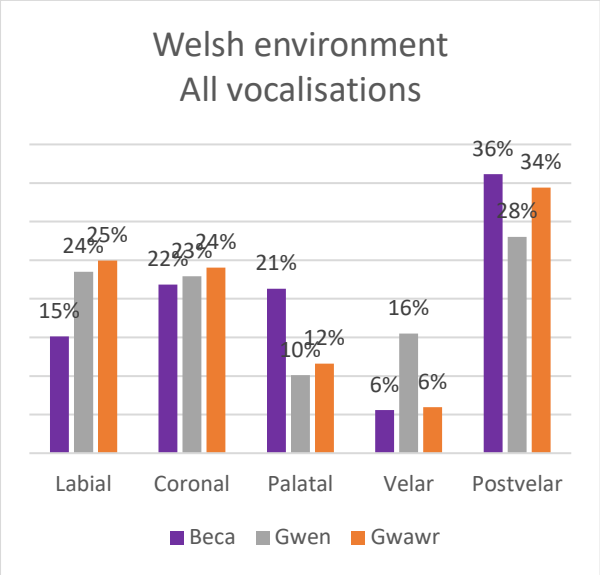


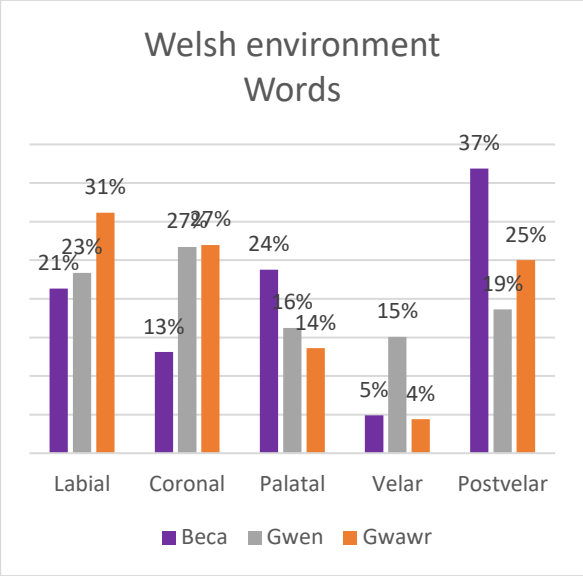


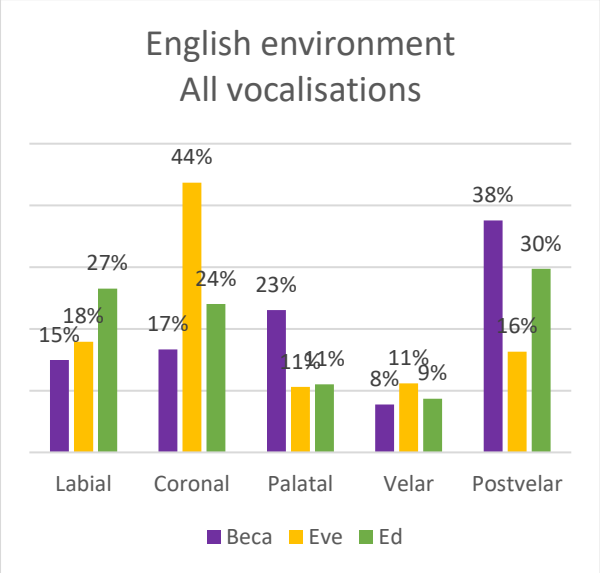


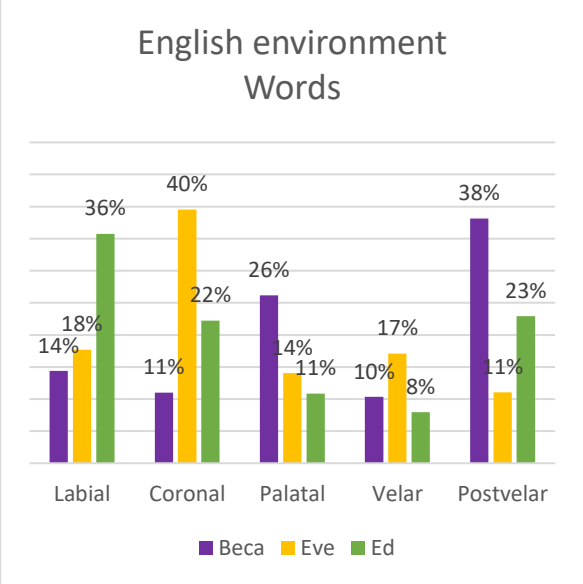


Appendix B3 - Occurrence of place of articulation categories for individual children



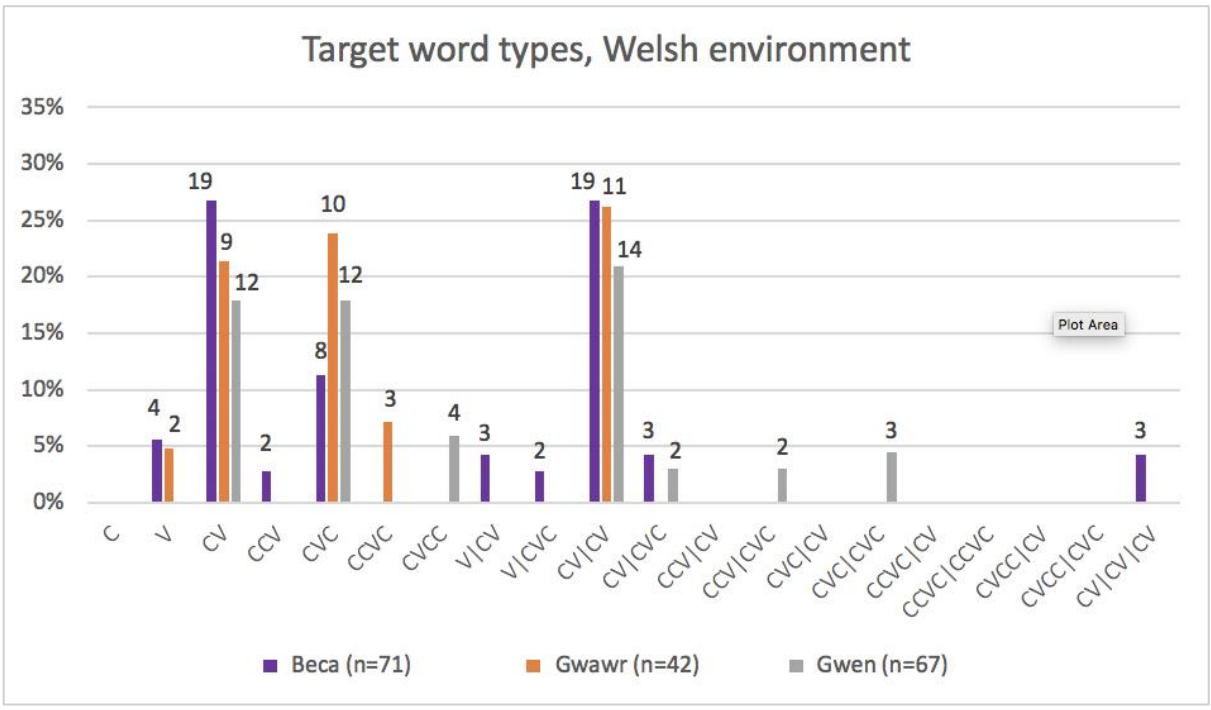


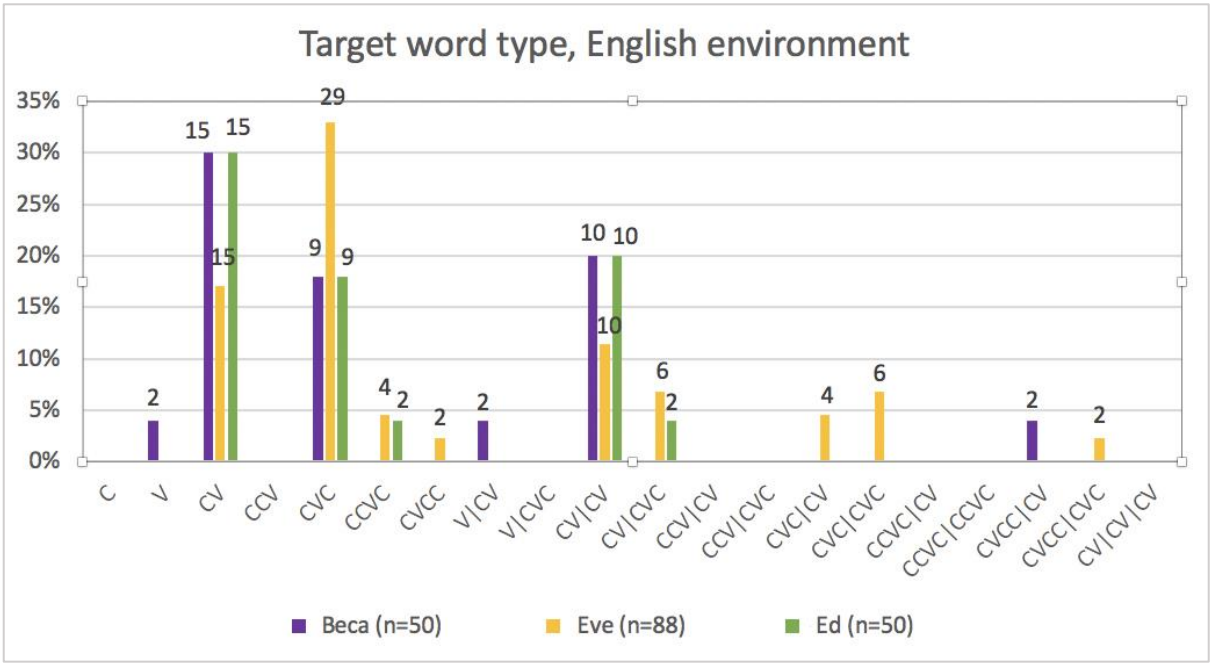




Appendix C (Chapter 5)

Appendix C1 - Individual Target Word Inventories





Appendix D (Chapter 6)

Appendix D1 – Number of vocalisations produced in each session

Welsh environment

Age (nearest month)	Dual language home						Single language home					
	Ben			Beca			Gwawr			Gwen		
	All	Words		All	Words		All	Words		All	Words	
		Types	Tokens		Types	Tokens		Types	Tokens		Types	Tokens
1;1							110	3	20	235	10	18
1;2				201	5	35						
1;3							117	13	20	328	24	94
1;4				490	21	77	227	21	66	514	57	176
1;5	247	3	12									
1;6				239	18	47	316	28	114			
1;7												
1;8	431	16	98									
1;9				681	59	318						
1;10												
1;11												
2;0												
2;1	576	22	313									
2;2												
2;3												
2;4												
2;5												
2;6	443	26	232									

English environment

Age (nearest month)	Dual language home						Single language home					
	Ben			Beca			Eve			Ed		
	All	Words		All	Words		All	Words		All	Words	
		Types	Tokens		Types	Tokens		Types	Tokens		Types	Tokens
1;1												
1;2				119	5	20	185	7	9			
1;3							149	6	13	139	3	22
1;4				234	16	28				257	12	36
1;5	129	0	0				231	8	44			
1;6				367	16	56				145	13	43
1;7							197	16	62			
1;8	401	12	116							282	22	50
1;9				584	31	204	143	18	68			
1;10							216	57	108	285	28	74
1;11												
2;0												
2;1	509	16	246									
2;2												
2;3												
2;4												
2;5												
2;6	357	20	151									

Appendix D2 – Type-token ratio calculation

	Welsh environment				English environment			
	Ben	Beca	Gwen	Gwawr	Ben	Beca	Eve	Ed
Number of novel types	35	71	67	43	34	50	88	50
Total tokens	382	373	270	175	272	250	296	164
Type/token ratio	0.09	0.19	0.25	0.25	0.13	0.20	0.30	0.30