Speech processing and morphological development in Greek-speaking children

By:

ELEFTHERIA GERONIKOU

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Faculty of Medicine, Dentistry and Health

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To the memory of my beloved father

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Contents

Acknowledgments i

Contents iii

List of tables ix

List of figures xv

List of appendices xviii

Abbreviations xix

Abstract 1

Chapter 1. Introduction – Language acquisition 2

1.1 The structure of the current thesis 2

1.2 The contribution of studying the Greek language 3

1.3 Morphological development 5

1.4 Phonological development 10

1.5 Studies in Greek speaking children with language difficulties 13

1.6 Factors influencing language acquisition 19

1.6.1 Speech perception 19

1.6.2 Short Term Memory (STM) 23

1.6.3 Phonological Awareness 28

1.7 Summary 34

Chapter 2. Assessment of speech and language in children 37

2.1 Clinical markers for identification of language difficulties: 37

2.1.1 Grammatical tasks 38

2.1.2 Nonword repetition 41

2.1.3 Sentence repetition 46

2.2 Speech processing skills and the psycholinguistic approach 52

2.2.1 Overview of speech processing and the psycholinguistic approach 52

2.2.2 The Stackhouse & Wells (1997) psycholinguistic framework........................... 53
2.3 Assessment of speech processing 56
2.3.1 Assessment of speech input 56
2.3.2 Assessment of phonological representations 57
2.3.3 Assessment of speech output 58
2.4 The psycholinguistic profile 60
2.5 Speech difficulties 61
2.5.1 Classification of speech difficulties 61
2.5.2 Description of speech characteristics 64
2.5.3 Intervention approaches 64
2.5.4 Effects of intervention on phonology and morphology 66
2.6 Summary 70
2.7 Aims of the study 74
Chapter 3. Methodology 75
3.1 Design 75
3.2 Participants of the normative study 75
3.3 Brief introduction to the tasks and materials used in the study 78
3.4 Published tests 79
3.4.1 Diagnostic Verbal IQ test (DVIQ, Tsimpli & Stavrakaki, 2001) 79
3.4.2 The Renfrew language scales 81
3.4.3 Athena Test, Assessment of Learning Difficulties 83
3.5 Experimental stimuli 85
3.5.1 Stimuli of morphological interest 85
3.5.1.1 Morphological minimal pairs 85
3.5.1.2 Non-words matched to morphological minimal pairs 87
3.5.2 Stimuli of phonological interest 89
3.5.2.1 Phonological minimal pairs 89
3.5.2.2 Nonwords based on phonological minimal pairs 90

3.6 Experimental tasks 94
3.6.1 Assessment of language production (supplementary blocks) 94
3.6.2 Assessment of language comprehension (supplementary blocks) 94
3.6.3 Nonword auditory discrimination 95
3.6.4 Real word auditory discrimination 96
3.6.5 Real word auditory discrimination with picture choice 97
3.6.6 Mispronunciation detection for polysyllabic words 98
3.6.7 Real word repetition 99
3.6.8 Nonword repetition 100
3.6.9 Segmentation task 101
3.6.10 Short term memory (STM) test 102
3.7 Data collection procedure 103
3.8 Inter rater reliability 105
Chapter 4. Development of language, speech processing, phonological awareness and short term memory skills: results of the normative study. 106
4.1 Development of language skills over time 108
4.1.1 Diagnostic Test of Verbal Intelligence (DVIQ) 108
4.1.2 Vocabulary (Renfrew word finding test) 114
4.1.3 Elicited language production 116
4.1.4 Language production in spontaneous speech sample 118
4.1.5 Summary 120
4.2 Development of speech processing skills over time 121
4.2.1 Is there a difference in performance for children of different ages in discrimination between speech sounds without reference to phonological and morphological representations? 121
4.2.2 Is there a difference in performance for children of different ages in discrimination between real words with different phonological and morphological properties? 124

4.2.3 Is there a difference in performance for children of different ages in accessing accurate phonological representations? 127

4.2.4 Is there a difference in performance for children of different ages in accessing accurate motor programs? 130

4.2.5 Is there a difference in performance for children of different ages in producing the phonological and morphological elements of real words accurately? 133

4.2.6 Is there a difference in performance for children of different ages in producing speech without reference to phonological and morphological representations? 139

4.3 Development of phonological awareness abilities over time 145

4.3.1 Development of blending abilities 145

4.3.2 Development of segmentation abilities 147

4.4 Development of Short Term Memory 149

4.5 Summary of findings 152

Chapter 5. Factors affecting the development of speech and language in Greek speaking children 154

5.1 Factors affecting performance on speech processing tasks 158

5.1.1 Linguistic domain effect 158

5.1.2 Word length effect 164

5.1.3 Lexicality effect 169

5.1.4 Level of processing effect 179

5.1.5 Modality of processing effect 181

5.2 Relationships between the development of speech processing, language and short term memory 187

5.2.1 The relationship between processing of phonological and morphological items within and across time 187

5.2.2 The relationship between input and output processing in typically developing children within and across time 191

5.2.3 The relationship between speech input processing and language development 197

5.2.4 The relationship between vocabulary development, accuracy of stored phonological representations and phonological awareness 200

5.2.5 The relationship between vocabulary production, language development and phonological awareness.. 206

5.2.6 The relationship between short term memory, language and speech processing 212

5.2.7 The relationship between production of polysyllabic items with short term memory, accuracy of stored phonological representations and segmentation skills 217

5.3 Summary of findings 221

Chapter 6. Intervention Case studies...225

6.1 Issues in single case study design – general principles in developing intervention 226

6.2 Background to the intervention case studies 227

6.3 Methodology... 230

6.3.1 Participants 230

6.3.2 Design.. 232

6.3.3 Intervention phases 232

6.3.4 Procedure and materials... 234

6.4 Results: Harry... 239

6.4.1 Performance on probe assessment 240

6.4.2 Performance on baseline assessment 244

6.5 Results: Anthi 252

6.5.1 Performance on probe assessment 253

6.5.2 Performance on baseline assessment 258

6.6 Summary of findings 265

Chapter 7. Discussion...267

7.1 The development of language and speech processing skills in Greek speaking children 267

7.1.1 Language tasks 268

7.1.2 Auditory discrimination tasks 269

7.1.3 Speech production tasks 272
7.1.4 Phonological awareness 274
7.1.5 Potential practice effects 275
7.1.6 Future directions – possible improvements to the test battery 276
7.2 Theoretical issues in speech and language development in typically developing Greek speaking children 278
7.2.1 Factors affecting development of speech processing 278
7.2.2 The relationships between different speech and language skills 287
7.2.3 Summary of normal speech processing development in Greek 295
7.2.4 The significance of investigating normal speech processing development in Greek 296
7.3 Intervention targeting phonological and morphological skills 298
7.3.1 Response to intervention 298
7.3.2 Evaluation of the intervention outcome for both case studies 302
7.3.3 Comments on intervention case studies 308
7.4 Concluding remarks 312
References 316
Appendices 342

List of tables

Table 1-1 Morphology of a regular verb /ˈðεno/ (tie) in Greek.. 5

Table 1-2 The use of morphemes in morphosyntactic context. 7

Table 1-3 Stages of phonetic and phonological development of Greek speaking children (PAL, 1995). 12

Table 3-1 Participants of the normative study 75

Table 3-2 Morphological stimuli 86

Table 3-3 Morphological minimal pairs 87

Table 3-4 Nonwords matched to stimuli of morphological interest... 88

Table 3-5 Phonological minimal pairs 89

Table 3-6 Nonwords matched on phonological minimal pairs 90

Table 3-7 Stimuli included in Mispronunciation detection task 91

Table 3-8 Nonwords based on real polysyllabic words.. 91

Table 3-9 Segmentation task stimuli... 92

Table 3-10 STM stimuli.. 93

Table 3-11 Order of tasks in each Session 103

Table 4-1 Descriptive Statistics for each age group on DVIQ Comprehension 109

Table 4-2 Descriptive Statistics for each age group on DVIQ Production............................. 109

Table 4-3 Descriptive Statistics for each age group on DVIQ Sentence Repetition............... 109

Table 4-4 Descriptive Statistics for each age group on DVIQ Comprehension Experimental 109

Table 4-5 Descriptive Statistics for each age group on DVIQ Production Experimental 109

Table 4-6 Descriptive Statistics for each age group on Renfrew Word Finding Test............. 114

Table 4-7 Descriptive statistics for each age group for Renfrew Action Picture test, Grammar Score 116

Table 4-8 Descriptive statistics for each age group for Renfrew Action Picture test, Information Score 116

Table 4-9 Descriptive statistics for each age group on Bus Story test Information Score...... 118

Table 4-10 Descriptive statistics for each age group on Bus Story test Mean Length of Utterance 118

Table 4-11 Descriptive statistics for each age group on Bus Story test production of Subordinate Clauses... 118

Table 4-12 Descriptive Statistics for each age group on Nonword Auditory Discrimination Phonological Task.. 122

Table 4-13 Descriptive Statistics for each age group on Nonword Auditory Discrimination Morphological Task 122
Table 4-14 Descriptive statistics for each age group on Real Word Auditory Discrimination Phonological Task 125
Table 4-15 Descriptive statistics for each age group on Real Word Auditory Discrimination Morphological Task 125
Table 4-16 Descriptive statistics for each age group on Mispronunciation Detection Task ... 127
Table 4-17 Descriptive statistics for each age group on Picture choice task 127
Table 4-18 Descriptive statistics for each age group on Naming Accuracy – Whole Word 130
Table 4-19 Descriptive statistics for each age group on Naming Accuracy – Percentage of Consonants Correct 130
Table 4-20 Descriptive statistics for each age group for accuracy of Real word Repetition Phonological – Whole Word 133
Table 4-21 Descriptive statistics for each age group for accuracy of Real word Repetition Morphological – Whole Word 133
Table 4-22 Descriptive statistics for each age group for accuracy of Real word Repetition Polysyllabic – Whole Word 134
Table 4-23 Descriptive statistics for each age group for accuracy of Real word Repetition Phonological – Percentage of Consonants Correct 134
Table 4-24 Descriptive statistics for each age group for accuracy of Real word Repetition Morphological – Percentage of Consonants Correct 134
Table 4-25 Descriptive statistics for each age group for accuracy of Real word Repetition Polysyllabic – Percentage of Consonants Correct 134
Table 4-26 Descriptive statistics for each age group for accuracy of Non - Word Repetition Phonological – Whole Word 139
Table 4-27 Descriptive statistics for each age group for accuracy of Non - Word Repetition Morphological – Whole Word 139
Table 4-28 Descriptive statistics for each age group for accuracy of Non - Word Repetition Polysyllabic – Whole Word 140
Table 4-29 Descriptive statistics for each age group for accuracy of Non - Word Repetition Phonological – Percentage of Consonants Correct 140
Table 4-30 Descriptive statistics for each age group for accuracy of Non - Word Repetition Morphological – Percentage of Consonants Correct 140

Table 4-31 Descriptive statistics for each age group for accuracy of Non - Word Repetition Polysyllabic– Percentage of Consonants Correct.. 140
Table 4-32 Descriptive statistics for each age group on blending tasks 145
Table 4-33 Descriptive statistics for each age group on Segmentation Task 147
Table 4-34 Descriptive statistics for each age group on STM number of Words recalled...... 149
Table 4-35 Descriptive statistics for each age group on STM number of word chunks recalled in the correct Order 149
Table 5-1 Paired samples comparison of performance between RWRep tasks for Group 2 . 161
Table 5-2 Paired samples comparison of performance between RWRep PCC tasks for linguistic domain Group 1 162
Table 5-3 Paired samples comparison of performance between RWRep PCC tasks for linguistic domain Group 2 163
Table 5-4 Paired samples comparison of performance between RWRep PCC tasks for word length for Group 1.. 165
Table 5-5 Paired samples comparison of performance between RWRep PCC tasks for word length for Group 2.. 166
Table 5-6 Paired samples comparison of performance between NWRep PCC for word length for Group 1.. 167
Table 5-7 Paired samples comparison of performance between NWRep PCC for word length for Group 2.. 168
Table 5-8 Paired samples comparison of performance in Polysyllabic items between real words and nonwords for group 2 176
Table 5-9 Paired samples comparison of performance in Nonwords of Morphological Interest between Auditory Discrimination and Repetition tasks for group 1 185
Table 5-10 Paired samples comparison of performance in Nonwords of Morphological Interest between Auditory Discrimination and Repetition tasks for group 2 185
Table 5-11 Correlations between performance on phonological and morphological items in real word auditory discrimination tasks for group 1 188
Table 5-12 Correlations between performance on phonological and morphological items in real word auditory discrimination tasks for group 2 188
Table 5-13 Correlations between performance on phonological and morphological items in real word repetition tasks for group 1 189
Table 5-14 Correlations between performance on phonological and morphological items in real word repetition tasks for group 2 190

Table 5-15 Correlations between performance on real word auditory discrimination and real word repetition for phonological items for group 1 ... 192
Table 5-16 Correlations between performance on real word auditory discrimination and real word repetition for phonological items for group 2 ... 192
Table 5-17 Correlations between performance on real word auditory discrimination and real word repetition for morphological items for group 1 ... 193
Table 5-18 Correlations between performance on real word auditory discrimination and real word repetition for morphological items for group 2 ... 193
Table 5-19 Correlations between performance on nonword auditory discrimination and nonword repetition for phonological items for group 1 ... 194
Table 5-20 Correlations between performance on nonword auditory discrimination and nonword repetition for phonological items for group 2 ... 194
Table 5-21 Correlations between performance on nonword auditory discrimination and nonword repetition for morphological items for group 1 ... 195
Table 5-22 Correlations between performance on nonword auditory discrimination and nonword repetition for morphological items for group 2 ... 195
Table 5-23 Correlations between performance on real word auditory discrimination for morphological items and language comprehension for group 1 ... 197
Table 5-24 Correlations between performance on real word auditory discrimination for morphological items and language comprehension for group 2 ... 198
Table 5-25 Correlations between performance on real word auditory discrimination for phonological items and vocabulary production for group 1 ... 199
Table 5-26 Correlations between performance on real word auditory discrimination for phonological items and vocabulary production for group 2 ... 199
Table 5-27 Correlations between performance on vocabulary production and real word auditory discrimination with picture choice for group 1 ... 201
Table 5-28 Correlations between performance on vocabulary production and real word auditory discrimination with picture choice for group 2 ... 201
Table 5-29 Correlations between performance on vocabulary production and mispronunciation judgment for group 1 ... 202
Table 5-30 Correlations between performance on vocabulary production and mispronunciation judgment for group 2 ... 202
Table 5-31 Correlations between performance on vocabulary production and naming accuracy for group 1 ... 203

Table 5-32 Correlations between performance on vocabulary production and naming accuracy for group 203
Table 5-33 Correlations between performance on vocabulary production and segmentation for group 1 204
Table 5-34 Correlations between performance on vocabulary production and segmentation for group 2 204
Table 5-35 Correlations between performance on vocabulary production and language comprehension for group 1 207
Table 5-36 Correlations between performance on vocabulary production and language comprehension for group 2 207
Table 5-37 Correlations between performance on vocabulary production and elicited language production for group 1 208
Table 5-38 Correlations between performance on vocabulary production and elicited language production for group 2 208
Table 5-39 Correlations between performance on vocabulary production and MLU for group 1 209
Table 5-40 Correlations between performance on vocabulary production and MLU for group 2 209
Table 5-41 Correlations between performance on language comprehension and segmentation for group 1 210
Table 5-42 Correlations between performance on language comprehension and segmentation for group 2 210
Table 5-43 Correlations between performance on language production and segmentation for group 1 211
Table 5-44 Correlations between performance on language production and segmentation for group 2 211
Table 5-45 Correlations between performance on STM tasks and Vocabulary production for group 1 213
Table 5-46 Correlations between performance on STM tasks and Vocabulary production for group 2 213
Table 5-47 Correlations between performance on STM tasks and language comprehension for group 1 214
Table 5-48 Correlations between performance on STM tasks and language comprehension for group 2 214

Table 5-49 Correlations between performance on STM tasks and language production for group 1 215
Table 5-50 Correlations between performance on STM tasks and language production for group 2 215
Table 5-51 Correlations between performance on STM Word order task and ABX auditory discrimination tasks for group 1 216
Table 5-52 Correlations between performance on STM Word order task and ABX auditory discrimination tasks for group 2 216
Table 5-53 Correlations between performance on Repetition of polysyllabic items and STM for group 1 218
Table 5-54 Correlations between performance on Repetition of polysyllabic items and STM for group 2 218
Table 5-55 Correlations between performance on Repetition of polysyllabic items and accuracy of stored representations for group 1 219
Table 5-56 Correlations between performance on Repetition of polysyllabic items and accuracy of stored representations for group 2 219
Table 5-57 Correlations between performance on Repetition of Polysyllabic items and segmentation skills for group 1 220
Table 5-58 Correlations between performance on Repetition of Polysyllabic items and segmentation skills for group 2 220
Table 6-1 Stimuli characteristics in probe assessment (number of items) 236
Table 6-2 Harry's performance on probe assessment across intervention Phases 239
Table 6-3 Harry's performance in probe assessment at pre and post intervention time points 242
Table 6-4 Harry's performance on baseline assessment compared to 4; 0 – 4; 5 years old children on the normative study 245
Table 6-5 Harry's performance in input tasks at pre and post intervention time points 247
Table 6-6 Harry's performance in output tasks at pre and post intervention time points 249
Table 6-7 Anthi's performance on probe assessment across intervention Phases 252
Table 6-8 Anthi's performance in probe assessment at pre and post intervention time points 257
Table 6-9 Anthi's performance on baseline assessment compared to 5;6 – 6;0 years old children on the normative study 259
Table 6-10 Anthi's performance in language tasks at pre and post intervention time points 261

Table 6-11 Anthi’s performance in output tasks at pre and post intervention time points... 263
Table 0-1 Selectivesample for interrater reliability 349

List of figures

Figure 4-1 Schematic representation of the time points and the age of the children in each group during data collection used for comparison of assessment performance in each task106
Figure 4-2 Performance on DVIQ Comprehension across time points 111
Figure 4-3 Performance on DVIQ Production across time points 111
Figure 4-4 Performance on DVIQ Sentence Repetition across time points 112
Figure 4-5 Performance on DVIQ Comprehension Experimental 112
Figure 4-6 Performance on DVIQ Production Experimental 112
Figure 4-7 Performance on Renfrew Word Finding Task across time points 115
Figure 4-8 Performance on Renfrew Action Picture Test Grammar score across time points117
Figure 4-9 Performance on Renfrew Action Picture Test Information score across time points 117
Figure 4-10 Performance on Renfrew Bus Story Information score across time points 119
Figure 4-11 Performance on Renfrew Bus Story Mean Length of Utterance across time points 120
Figure 4-12 Performance on Renfrew Bus story production of Subordinate Clauses across time points 120
Figure 4-13 Performance on discrimination of speech sounds without reference to phonological representations across time points... 123
Figure 4-14 Performance on discrimination of speech sounds without reference to morphological representations across time points 123
Figure 4-15 Performance on Real Word Auditory Discrimination of Phonological items across time points 126
Figure 4-16 Performance on Real Word Auditory Discrimination Morphological items across time points 126
Figure 4-17 Performance on Picture Choice of Phonological Minimal pairs across time points 128
Figure 4-18 Performance on Mispronunciation Detection of Polysyllabic items across time points 129
Figure 4-19 Performance on Naming accuracy, whole word scoring across time points....... 131

Figure 4-20 Performance on Naming Accuracy, Percentage of Consonants Correct scoring across time points 132
Figure 4-21 Performance on Real Word Repetition of Phonological items, whole word scoring across time points 136
Figure 4-22 Performance on Real Word Repetition of Morphological items, whole word scoring across time points 136
Figure 4-23 Performance on Real Word Repetition of Polysyllabic items, whole word scoring across time points 136
Figure 4-24 Performance on Real Word repetition of Phonological items, Percentage of Consonants Correct scoring across time points 137
Figure 4-25 Performance on Real Word repetition of Morphological items, Percentage of Consonants Correct scoring across time points 137
Figure 4-26 Performance on Real Word repetition of Polysyllabic Words, Percentage of Consonants Correct scoring across time points 137
Figure 4-27 Performance on production of speech sounds without reference to phonological representations whole word scoring across time points 142
Figure 4-28 Performance on production of speech sounds without reference to morphological representations whole word scoring across time points 142
Figure 4-29 Performance on production of speech sounds without reference to representations for polysyllabic items whole word scoring across time points 142
Figure 4-30 Performance on production of speech sounds without reference to phonological representations, percentage of consonants correct scoring across time points 143
Figure 4-31 Performance on production of speech sounds without reference to morphological representations, percentage of consonants correct scoring across time points 143
Figure 4-32 Performance on production of speech sounds without reference to representations for polysyllabic items percentage of consonants correct scoring across time points 143
Figure 4-33 Performance on Blending task across time points 146
Figure 4-34 Performance on segmentation task across time points 148
Figure 4-35 Performance on the number of words correctly recalled across time points 150
Figure 4-36 Performance on the number of word chunks recalled in the correct order across time points 151
Figure 5-1 Real Word Auditory Discrimination for items of phonological and morphological interest across time points 159

Figure 5-2 Real Word repetition for items of phonological and morphological interest across time points 160
Figure 5-3 RW Rep PCC for items of phonological and morphological interest across time points 162
Figure 5-4 RW Rep PCC for items of standard length and polysyllabic items across time points 165
Figure 5-5 NW Rep PCC for items of standard length and polysyllabic items across time points 167
Figure 5-6 Auditory Discrimination of RW and NW Phonological items across time points .. 170
Figure 5-7 Auditory Discrimination of RW and NW Morphological items across time points 171
Figure 5-8 Repetition of RW and NW Phonological items scored for whole word accuracy across time points 172
Figure 5-9 Repetition of RW and NW Phonological items scored for PCC accuracy across time points 173
Figure 5-10 Repetition of RW and NW Morphological items scored for whole word accuracy across time 174
Figure 5-11 Repetition of RW and NW Morphological items scored for PCC across time 175
Figure 5-12 Repetition of RW and NW Polysyllabic items scored for whole word accuracy across time 177
Figure 5-13 Repetition of RW and NW Polysyllabic items scored for whole word accuracy across time 178
Figure 5-14 Real Word Auditory Discrimination in ABX and Picture Choice tasks across time points 180
Figure 5-15 Input and Output processing of Real Words of phonological interest across time points 182
Figure 5-16 Input and Output processing of Real Words of morphological interest across time points 183
Figure 5-17 Input and Output processing of Nonwords of phonological interest across time points 184
Figure 5-18 Input and Output processing of Nonwords of morphological interest across time 186
Figure 6-1 Research design 232

List of appendices

Appendix 1: DVIQ Production of morphology and syntax 342
Appendix 2: Comprehension of morphology and syntax 345
Appendix 3: Sentence repetition 347
Appendix 4: Blending task 348
Appendix 5: procedure followed for the interrater reliability scoring 349
Appendix 6: Treated items on intervention phase 1 352
Appendix 7: Treated items on intervention phase 2 353
Appendix 8: Treated items on intervention phase 3 354
Appendix 9: Treated items on Intervention phase 4 355
Appendix 10: Probe assessment items 356
Appendix 11: Short session plan for intervention phase 1 357
Appendix 12: Short session plan for Intervention phase 2 358
Appendix 13: Short sessions plan for intervention phase 3 359
Appendix 14: Short session plan for intervention Phase 4 360
Appendix 15 Detailed session Plan: Phase 1(focus phonological): Session1 361
Appendix 16 Detailed session Plan Phase 1 (focus phonological): Session 2 363
Appendix 17 Detailed session Plan Phase 2 (focus morphological): Session 3 365
Appendix 18 Ethical approval confirmation letter for the longitudinal study 367
Appendix 19 Ethical approval confirmation letter for intervention case studies 368

Abbreviations

List of abbreviations	
DVIQ	Developmental verbal IQ test (Tsimpli
DVIQC	DVIQ comprehension subtest
DVIQP	DVIQ production subtest
DVIQ SR	DVIQ sentence repetition subtest
DVIQCExp	Experimental task of language comprehension, based on DVIQ items
DVIQPExp	Experimental task of language production, based on DVIQ items
ActionGr	Renfrew Action Picture test, Grammar Score
ActionInf	Renfrew Action Picture test, Information Score
BusInf	Renfrew Bus Story Test, Information Score
BusMLU	Renfrew Bus story Test, MLU of 5 longest sentences
BusSub	Renfrew Bus story Test, production of Subordinate clauses
Vocab	Renfrew word finding test, Vocabulary production
RWAudDPhon	Real Word Auditory Discrimination, stimuli of Phonological Interest
RWAudDMor	Real Word Auditory Discrimination, stimuli of Morphological Interest
NWAudDPhon	Nonword Auditory Discrimination, matched on stimuli of Phonological Interest
NWAudDMor	Nonword Auditory Discrimination, matched on stimuli of Morphological Interest
RWPicCh	Real Word Picture Choice - phonological
MisprD	Mispronunciation Detection
Naming	Naming
RWRepPhon	Real Word Repetition, stimuli of Phonological Interest
RWRepMor	Real Word Repetition, stimuli of Morphological Interest
RWRepPol	Real Word Repetition, polysyllabic stimuli
NWRepPhon	Nonword Repetition, matched on stimuli of Phonological Interest
NWRepMor	Nonword Repetition, matched on stimuli of Morphological Interest
NWRepPol	Nonword Repetition, matched on polysyllabic stimuli
PCC	Percentage of Consonants Correct
WW	Whole Word accuracy
STM	Short term memory
MemoryW	Number of words recalled
MemoryO	Chunks of words recalled in the correct Order
SR	Sentence Repetition
Segm	Segmentation task
Blend	Blending task
SSD	Speech Sound Disorders

Abstract

Speech processing and morphological development in Greek-speaking children

There is currently little knowledge about the development of morphology in relation to phonology and the speech processing system (speech input, speech output, and lexical representations). In this thesis a psycholinguistic approach was used to investigate the development of phonological and morphological skills in Greek speaking preschool age children. The central hypothesis is that the successful acquisition of phonological and morphological characteristics of a spoken language depends on the accuracy and efficiency of speech processing skills. This has been explored through a longitudinal normative study of speech and language development and two intervention single case studies of children with speech difficulties.

Two groups of typically developing children aged 3;0-3;5 and 4;6-5;0 years respectively were assessed longitudinally at three assessment points six months apart. At each point published language assessments and experimental tasks were used. A number of morphological phenomena e.g. tense, possessive pronouns, irregular plural, were taken as the basis for experimental stimuli that reflected the morphological and phonological properties of interest. These stimuli were used in tasks of speech perception and word and nonword repetition, items being matched across tasks. The two intervention studies focused on the impact of training the production of phonological targets on the accuracy of morphological productions, and vice versa, as well as the effect of this training on broader speech and language processing skills.

Significant processing similarities were found between phonological and morphological items, as were relationships between the two domains. Both intervention case studies indicated that as a result of targeting the accurate production of morphemes, generalization to the accurate production of phonological characteristics may occur; one case also supported the reverse effect. Overall, these results suggest that the morphological characteristics of spoken language are an integral part of lexical representations, a finding which has interesting implications for speech and language therapy practice.

Chapter 1. Introduction – Language acquisition

1.1 The structure of the current thesis

This thesis examines the role of speech processing in language development and in particular in morphological development. This work takes the form of a normative study that investigates the development of language and speech processing abilities in Greek children aged 3;0 - 6;0 years. Furthermore two intervention case-studies of children with speech difficulties within this age explore the extent to which speech therapy to develop phonological or morphological skills impacts on the development of speech, language or both.

The overall structure of the study takes the form of seven chapters, including this introductory chapter. Chapter One describes the characteristics of the Greek language and reviews current knowledge on typical and atypical development in Greek speaking children. Factors affecting language development are discussed.

Chapter Two begins by laying out the theoretical dimensions of the research, and looks at how children with speech and / or language difficulties are assessed and diagnosed. Emphasis is put on the psycholinguistic approach to the assessment of children with speech and language difficulties. The aims and objectives of the study are set.

The third chapter is concerned with the methodology used for the normative study. Published and experimental tasks are presented.

The fourth chapter presents the findings of the normative study, focusing on the changes that occur on speech processing and language abilities over time.

The fifth chapter examines two key themes: first, factors affecting speech and language development and the potential links between different levels of speech processing; and second, correlations between speech processing and language and in particular phonological and morphological components of language.

Chapter six presents the theoretical framework, methodology and delivery of intervention for two children with speech difficulties. The short term and long term outcomes of intervention are discussed.

The final chapter draws upon the entire thesis, tying up the various theoretical issues and experimental findings and includes a discussion of the implication of the findings for clinical practice and future research into this area.

1.2 The contribution of studying the Greek language

In general there is limited knowledge on Greek language development. There are theoretical and practical reasons for studying the Greek language.

Theoretical reasons arise from the fact that there is a considerable amount of evidence on the production and comprehension of English by children with Specific Language Impairment (SLI). However data from languages other than English may suggest hypotheses that might not have been considered on the basis of English data alone (Leonard, 1998). According to Leonard (2000) several cross-linguistic generalizations can be made about the use of grammatical morphology by children with SLI. Children with SLI who are acquiring a language with a rich inflectional morphology seem less impaired in the use of grammatical inflections than their counterparts who are acquiring a language with a sparse inflectional morphology such as English (Leonard, 2000). Greek is a highly inflected language thus studying Greek could reveal some language specific errors that would contribute to the understanding of both typical and atypical language development. Cross linguistic studies from children with specific language impairment speaking Italian (Bortolini, Caselli, & Leonard, 1997), Spanish (Bedore & Leonard, 1999), Hebrew (Dromi, Leonard, Adam, & Zadunaisky-Ehrlich, 1999) and English (Leonard, Eyer, Bedore & Grela, 1997) indicate that in a language in which all verbs are inflected, with regard to the use of inflections errors of substitution can occur, but errors of omission do not. However, the frequency of omission errors regarding auxiliary verbs, clitics and definite articles is comparable to that reported for English speaking children. 'Children with SLI who hear a language with obligatory noun, verb and adjective inflections will use such inflections much more readily than children with SLI whose language permits bare stems and contains only a small number of inflections' (Leonard, 1998, p. 117). Even when grammatical use of morphemes is weak, errors reflecting application of rules can be identified (Leonard, 2000).

The study of Greek as a language with a complex morphological system could shed light on aspects of development that may not be feasible to study in morphologically simpler languages.

The complexity of the morphological system leads to a different way of studying different languages, for example in morphologically rich languages such as Greek the mean length of utterance is calculated by dividing the number of words into the number of sentences (Marinis, 2003). However in the study of languages with less fusional morphology as in English MLU is calculated on the bases of number of morphemes and the number of sentences.

There are many morphologically rich languages such as Italian(Bortolini, Caselli, & Leonard, 1997), Spanish (Bedore & Leonard, 1999) or Hebrew (Dromi, Leonard, Adam, & Zadunaisky-Ehrlich, 1999)however, the use of polysyllabic stems is something found in particular in Greek (Aidinis & Nunes, 2001; Setatos, 1974). Greek children have to process polysyllabic stems for commonly used words such as [kɐrɐˈmɛl-ɐ] *(candy),* [mɐrmɛˈlɐð-ɐ] *(jam),* [ɐftoˈcinit-o] *(car),* [poˈðilɐt-o] *(bike)* and to combine these stems with the appropriate morpheme for case and number (Holton, Mackridge, Philippaki-Warburton, 1997; Klairis & Babiniotis, 2004) such as [-ɐ] for a feminine noun in the nominative case of singular, [-o] for a neutral noun in the nominative case in singular, [- ɐ] for a neutral noun in the nominative case in plural for example [poˈðilɐt-o] *(bike)* - [poˈðilɐt-ɐ] *(bikes).* Therefore, there may be impact of this language-specific factor on language development and cognitive skills such as short term memory.

There is also a practical interest and need to expand our knowledge on language development in typically developing Greek speaking children. Most of the studies conducted so far in Greek focussed mainly on the investigation of phonological awareness and written language development (Aidinis & Nunes, 2001; Nikolopoulos, Goulandris, Hulme & Snowling, 2006; Ioannou, 2010). There is limited research on the acquisition of morphology in early language development. Greater knowledge of trajectories of oral language development in the early years would enable clinicians to deliver better informed assessment and intervention.

This chapter will provide an overview of Greek morphology and phonology and what is already known about typical development. Subsequently studies investigating language acquisition and disorders in Greek speaking children will be presented. Then the role of other factors that are related to language development i.e. speech perception, short term memory and phonological awareness will be presented and findings for Greek speaking children will be discussed.

1.3 Morphological development

Greek is a highly inflected language characterised by a variety of morphemes used to indicate the grammatical status of words such as gender (masculine – feminine – neutral), number (singular – plural), case (nominative, genitive, accusative), person (1st, 2nd, 3rd), tense and voice (active – passive). In Greek, verbal morphology marks three persons and two numbers (Holton et al. 1997; Klairis & Babiniotis 2004). Third person singular has been claimed to be the most unmarked form of the inflectional paradigm because it is used in adult Greek in impersonal constructions where no thematic subject is required (Tsimpli 1992, 1996), for example /ˈvrɛçi/ (*it is raining*) – no subject is mentioned and the verb is used in the 3rd person singular. Furthermore, the 3rd person singular form of the verb involves the suffix -i (e.g. /ˈðɛni/ ‘*ties*’). This suffix is also used in the non-finite form of the verb (see Table 1-1 e.g. /ˈɛxo ˈðɛsi/ ‘*I have tied’*) (Varlokosta, Vainikka, & Rohrbacher, 1996, 1998; Klairis & Babiniotis 2004).

Table 1-1 Morphology of a regular verb /ˈðɛno/ (tie) in Greek

Active voice

	Simple present	Past continuous	Simple past	Simple future
1st s	ˈðɛno	ˈɛðɛna	ˈɛðɛsa	θa ˈðɛso
2nd s	ˈðɛnis	ˈɛðɛnɛs	ˈɛðɛsɛs	θɐ ˈðɛsis
3rd s	ˈðɛn i	ˈɛˈðɛnɛ	ˈɛðɛsɛ	θɐ ˈðɛs i
1st pl	ˈðɛnumɛ	ˈðɛnɐmɛ	ˈðɛsɐmɛ	θɐ ˈðɛsumɛ
2nd pl	ˈðɛnɛtɛ	ˈðɛnɐtɛ	ˈðɛsɐtɛ	θɐ ˈðɛsɛtɛ
3rd pl	ˈðɛnun	ˈɛðɛnɐn	ˈɛðɛsɐn	θɐ ˈðɛsun
	Future continuous	**Present perfect**	**Past perfect**	**Future perfect**
1st s	θɐˈðɛno	ˈɛxo ˈðɛs i	ˈixɐ ˈðɛs i	θɐ ˈɛxo ˈðɛs i
2nd s	θɐ ˈðɛnis	ˈɛçis ˈðɛs i	ˈiçɛs ˈðɛs i	θɐ ˈɛçis ˈðɛs i
3rd s	θɐ ˈðɛn i	ˈɛçi ˈðɛs i	ˈiçɛ ˈðɛs i	θɐ ˈɛçi ˈðɛs i
1st pl	θɐ ˈðɛnumɛ	ˈɛxumɛ ˈðɛs i	ˈixɐmɛ ˈðɛs i	θɐ ˈɛxumɛ ˈðɛs i
2nd pl	θɐ ˈðɛnɛtɛ	ˈɛxɛtɛ ˈðɛs i	ˈixɐtɛ ˈðɛs i	θɐ ˈɛxɛtɛ ˈðɛs i
3rd pl	θɐ ˈðɛnun	ˈɛxun ˈðɛs i	ˈixɐn ˈðɛs i	θɐ ˈɛxun ˈðɛs i

Red morphemes used to indicate different person and number
Blue infinitive form of the verb
Green modal corresponding to will for future tense

Verbs are inflected for person, number and tense. The inflections for a regular verb in active voice appear in Table 1-1. For example *–o* is indicative of first person singular; *–umε* is indicative of first person in plural and *–εtε* is indicative of second person in plural. The same endings are used in auxiliary verb in perfect tenses. Prefix *ε*- is indicative of past tense.

With regard to the verb conjugation system Greek is a null subject language. Even if the subject of the verb is not mentioned, it can be inferred by the verb suffix. Agreement appears in all verb forms, regardless of Mood, Time and Voice discrimination (Tsimpli, 2001). A verb stem includes morphological indication of aspect (for example in Table 1-1 stem /ðεn/ indicates present in active voice and stem /ðεs/ non present i.e. past – future tense in active voice). A verb suffix includes morphological marker of agreement for the correct person and number (Tsimpli, 2001). For instance when the verbal type /ˈðεno/ occurs in a sentence, the verb suffix *–o* indicates that the subject is in the first person singular, i.e. that the subject is *'I'*. When the verbal type /ˈðεnis/ occurs in a sentence, the verb suffix *–is* indicates that the subject is in the second person singular, i.e. that the subject is *'You'* (see Table 1-1).

The selection of the appropriate suffix is heavily influenced by the grammatical status and the syntactic role of a word; this means that person and number of the verb agree with person and number of the subject. Table 1-2 presents the differentiation in the suffix of the verb *–un* as opposed to *-i* when the subject of the verb refers to many people *(teachers*) and when the subject of the verb is only one person (*the teacher*) respectively.

There is a strong interdependence between morphology and syntax (Nikolopoulos, Goulandris, Hulme, & Snowling, 2006). The subject of each verb used in a sentence has to be in the nominative case and the object in the accusative (less often genitive) case respectively. Table 1-2 presents the differentiation in the suffix use of the noun depending on the syntactic role. For instance, the suffix for the nominative case *–is* is attached to the noun form /mɐθiˈtis/ when the noun is used in subject position, whereas the suffix for the accusative case *–i* is attached to the noun form /mɐθiˈti/ when the noun is used in object position. In Modern Greek there is no dative case as in ancient Greek and Latin. Indirect object is marked with prefix *s*- to the article that precedes the noun. In the case presented in Table 1-2 direct and indirect object are both in the accusative case, but they differ in prepositional prefix *s*- (*to*) that is attached to the article of the indirect object.

Reference to a noun that is already known can be made by using pronouns and clitics. Personal and demonstrative pronouns take the form of a strong / full pronoun for example /ɐˈfton/ (*him*), /ɐˈfto/ (it). Pronouns can also take the form of weak / clitic pronouns that are monosyllabic, unstressed forms, derived from full pronouns (Smith, 2008) for example /ɐˈfton/ → /ton/ (*him*), /ɐˈfto/ → /to/ (*it*). Clitics have to be marked within the sentence with the same features of agreement as the referent noun. Clitic pronouns are marked for: a) number, for example /ɐˈfton/ (*him*) (singular) - /ɐˈftus/ (*them*) (plural); b) case, for example /ɐˈfton/ (*him*) (accusative) /ɐˈftu/ (*his*) (genitive); and c) person (1st, 2nd and 3rd), for example /ɐˈfton/ (*him*) is a 3rd person pronoun. The 3rd person clitic pronouns are additionally marked for gender, for example /ton/ (*him*) masculine, /to/ (it) neutral. 'Clitics may be expletives, clitics need a prominent discourse antecedent to be interpreted, clitics can be impersonal, non-referential and non-human' (Tsimpli & Stavrakaki, 1999 p. 38). Table 1-2 demonstrates how an object clitic can be used in a grammatical sentence instead of a noun. All the articles used in the examples presented in Table 1-2 are definite articles. Definite articles are historically derived from demonstrative pronouns. A definite article, similarly to a clitic, is compatible with a referential interpretation. It is worth noting that articles are always morphologically marked for gender, number and case as in the examples that have been presented for clitics.

Table 1-2 The use of morphemes in morphosyntactic context.

Subject	Verb	Direct object	Indirect object
/i ˈðaskali	ˈðinun	to viˈvlio	stus maθiˈtɛs/
(The teachers	give	the book	to the students)
/o ˈðaskalos	ˈðini	to viˈvlio	sto maθiˈti/
(The teacher	gives	the book	to the student)
/o maθiˈtis	ˈðini	to viˈvlio	sto ˈðaskalo/
(The student	gives	the book	to the teacher)
/o maθiˈtis to	ˈðini		sto ˈðaskalo/
(The student	gives	it	to the teacher)
(object clitic)			

Red verb ending – agreement with the subject number
Blue noun ending – depending on the syntactic role
Green artictle ending – agreement with noun gender, case, number

There is limited research on the acquisition of morphology in the early language development of Greek-speaking children. As it concerns verbal morphology, Katis (1984) used a longitudinal dataset of one typically developing Greek-speaking girl, Marilena, between the ages of 2;6–4;0, alongside cross-sectional data from 21 children with an age range of 2;0–4;11. The cross-sectional sample showed that singular emerged earlier and was more frequent than plural. Doukas & Marinis (2012) examined the acquisition of person and number morphology in a dataset of two monolingual Greek-speaking children. They collected data on a monthly basis from two monolingual Greek speaking girls between the ages of 2;0 – 2;8 for the first and 1;7 – 2;11 for the second. Their results suggested that person and number morphology is used correctly and productively from that very early age of less than three years in Greek speaking children (Doukas & Marinis, 2012).

With regard to noun morphology, according to Christofidou (1998) plural initially appears in nouns that in adult language are mainly used in the plural such as [poɾtoˈkɐʎɐ] (oranges) and these nouns are less frequently used in singular such as [poɾtoˈkɐli] (orange). Research suggests that very young children at the stage of single word utterances tend to use nouns, verbs and adjectives. Children make appropriate use of certain morphemes such as the plural morpheme mentioned in the example above, however use of specific morphemes is restricted to specific words.

It is hypothesized that very young children memorize the nouns and verbs as a whole unit and do not analyze them into word stem and suffix. Spontaneous output at this stage does not provide indisputable evidence that children are aware of the morphology of the language they are learning (Marinis, 2008). The production of complex morphological types in languages such as Greek does not necessarily mean that the child has already acquired the knowledge relating to the grammatical declaration of various morphemes. In many cases it is possible for the child to replicate from memory several complex grammatical types and only later discover the rules (Katis, 1992).

It has been suggested that in morphologically rich languages like Greek the words of a child from the outset contain grammatical endings and prefixes (Stephany, 1981). Inflected verbs like /ˈcitɐ/ *'look'* with suffix *-ɐ* for the imperative, /ˈɛpɛsɛ/ *'fell'* with prefix *-ɛ* for the past tense, and suffix *-ɛ* for the third person in singular number seem to be among the first words of the children learning Greek. This may be explained simply as in languages such as Greek the production of bare word stems without the presence of a suffix for inflected words is never found in the adult language and is therefore ungrammatical (Katis, 1992).

When morphemes belonging to functional categories which are of a purely grammatical nature commence to emerge, children use them in a lexically based fashion, i.e. in conjunction with a limited number of words and in specific linguistic environments (Christofidou, 1998; Marinis 2002, 2003; Stephany, 1997). The productive use of syntax and morphology is an indication that the child has begun to conquer the syntax and morphology of the language he/she is learning. However, there is disagreement about the nature of knowledge available to the children at this stage. According to the generative theory Tsimpli (1996) suggests that when the child correctly uses free and inflected morphemes corresponding to functional categories productively and their usage rate reaches 90 % the child has acquired the concrete structure and has knowledge of abstract syntactic structures. Marinis (2003) suggests that marked structures or structures that involve movement are acquired later. In contrast, constructivist theory (Tomasello, 2003) would suggest that many of these phrases are based on word combinations that are frequent in their environment. Children begin language acquisition by learning to use some adult expressions (Tomasello, 2003) or expressions used by older siblings (Barton & Tomasello, 1994) as holophrases, without analyzing these phrases. Then children have to engage in a process of segmentation of the speech stream with regard to the communicative intentions so as to determine the association (Tomasello, 2003). Unfortunately there are no clear indications with respect to the ages at which different elements are acquired by children learning Greek.

Information on the development of morphology is necessary in order to investigate the contribution of speech processing skills for the comprehension and production of the morphological characteristics of language. Studies presented so far describe the acquisition of morphology on the basis of language production. These studies are based on data from a limited number of children (for example Katis (1984) reports on one participant, Doukas & Marinis (2012) on two participants), for a limited period of time, commonly some months of data collection. They are based on spontaneous speech data, which may not exhibit the range of linguistic competence of a child, for the reason that a child may not use certain structures he/she is able to use, if context and communicative conditions do not require their use.

1.4 Phonological development

Greek has 31 consonants (including allophones and affricates) and five vowels. The voiceless plosives are unaspirated and the voiced plosives are fully prevoiced (Mennen & Okalidou, 2007). Greek, unlike most other languages, contrasts voiced and voiceless palatal and velar fricatives, while interdental fricatives are also used (Ladefoged, 2001).

The consonant system of Greek comprises voiceless and voiced plosives, fricatives, nasals, and liquids [p, b, t, d, k, g, c, ɟ, f, v, θ, ð, s, z, x, ɣ, ç, j, m, n, ɾ, l, ʎ] (Arvaniti, 1999). Any consonant can be used in syllable initial and word initial or within word position. A limited number of consonants / ɾ, l, θ, n/ can be used in syllable final word within position and only /s, n/ can be used in syllable final, word final position (Mennen & Okalidou, 2007).

Common allophones in Greek are [k, c], [g, ɟ], [x, ç], [ɣ, j]. The velar ones are used preceding vowels /ɐ, o, u/ and the palatal ones are used preceding vowels /ɛ, i/. However, in written language there is one grapheme for example <κ> corresponding to both phonemes [k, c] of the allophone pair. Allophones orthographically are represented in the same way.

Greek also has a rich system of 65 consonant clusters used in word-initial and word-within position such as /sk, st, sp, kɾ, tɾ, pɾ, kl, pl/. Consonant clusters are never used in syllable final position (Mennen & Okalidou, 2007).

Greek has a typical five vowel system /ɐ, ɛ, i, o, u/ (Arvaniti, 1999). Greek is a language with "dynamic" stress; stressed syllables are distinguished by being generally longer and/or having higher amplitude than unstressed syllables (Arvaniti, 1999).

The syllable structure of Greek can be described in the formula $C_{(0-3)}VC_{(0-1)}$ (Mennen & Okalidou, 2007). Greek, however, has a tendency to have open syllables (Holton, Mackridge, & Philippaki-Warburton, 1998; Nikolopoulos et al., 2006). Most words tend to be bi-syllabic or multi-syllabic (Setatos, 1974). Usually high frequency content words consist of three syllables or more, whilst the number of monosyllabic nouns is limited (Aidinis & Nunes, 2001).

Research data suggest that the first syllabic structures to appear in a child's speech are open type syllables (Kappa, 1999) that consist of plosives, nasals and laterals plus a vowel (Kappa, 1999; Magoula, 2000). Then appear the palatal fricatives (and their allophones) and subsequently dental fricatives and trills (Magoula, 2000). The voicing contrasts are fully acquired by the age of three years (Magoula, 2000; Okalidou et al., 2002). A few studies have investigated the development of syllable structure and word length in Greek (PAL, 1995; Kappa, 2002; Tzakosta 2005). Kappa (2002) reported a case study of a typically developing girl from 1;7 – 3;0 years of age. Her first word productions were usually bisyllabic and often also trisyllabic with reduplicated syllables, whereas syllable reductions were made in multisyllabic words. The syllabic structure was CV and for words containing clusters she simplified her output by retaining the less sonorous element. Tzakosta (2005) provided evidence that, despite the multisyllabic nature of Greek, truncations of words may occur for typically developing children aged 1; 7 – 3; 6 years. Papathanasiou, Dimitrakopoulou, Ntaountaki & Vasilou (2012) report that 2-syllable, 3-syllable and multisyllabic words which consist of open syllables are accurately produced by four year old children, whereas closed syllables are only accurate in word final and not in word within position. Their data indicate that no phonological processes are active in children aged 4; 0 – 6; 0 years and that the phonetic inventory is fully developed by the age of 5; 6 to 6; 0.

The Panhellenic Association of Logopedics (PAL, 1995) conducted a survey of phonetic and phonological development of Greek children in a sample of 300 children aged 2;6 to 6;0 years in the Attica region (central Greece). To consider that a phoneme or cluster of consonants had been mastered in one age group, the researchers set the criterion of 75% of children in this group to have integrated the particular phoneme/ cluster in their system. Detailed information about the phonemes that constitute the phonetic inventory at each age group and the phonological processes occurring throughout the developmental stages is presented in Table 1-3 Stages of phonetic and phonological development of Greek speaking children (PAL, 1995). The survey data (PAL, 1995) indicate that greater activity in the development of consonant clusters is observed between 3; 6 - 4; 6 years (as it can be seen in Table 1-3).

Table 1-3 Stages of phonetic and phonological development of Greek speaking children (PAL, 1995).

	Phonetic inventory	Simplification processes: Structural	Simplification processes: Systemic
STAGE I (2;6 – 3;0)	m (n) ɲ p b t (d) c ɟ k g (f)(v) (ç), (ʝ) (x) (ɣ) (l) (ʎ)	• Reduction of consonant clusters • Phoneme or cluster deletion • Deletion of close syllable final phoneme • Harmony • Metathesis - transposition	• Fronting • Backing • Stopping
STAGE II (3;0 – 3;6)	m n ɲ p b t d c ɟ k g (f) v (θ)(ð) (s)(z) ç ʝ x ɣ (ts)(dz) (l) (ʎ)	• Syllable deletion • Deletion of close syllable final phoneme • Harmony • Metathesis – transposition • Reduction of consonant clusters	• Stopping
STAGE II (3;0 – 3;6)	m n ɲ p b t d c ɟ k g f v (θ) (ð) s z ç ʝ x ɣ (ts)(dz) l ʎ	• Syllable deletion • Deletion of close syllable final phoneme • Metathesis – transposition • Some consonant clusters except of /r/ clusters emerge	
STAGE III (3;6 – 4;0)	m n ɲ p b t d c ɟ k g f v θ ð s z ç ʝ x ɣ (ts)(dz) l (ɾ) ʎ	• Deletion of close syllable final phoneme within word • Clusters with plosives and / ɾ / emerge	
STAGE IV (4;0 – 4;6)	m n ɲ p b t d c ɟ k g f v θ ð s z ç ʝ x ɣ (ts)(dz) l (ɾ) ʎ	• Deletion of close syllable final phoneme within word • Clusters with fricatives and / ɾ / emerge	
STAGE V (4;5 – 5;0)	m n ɲ p b t d c ɟ k g f v θ ð s z ç ʝ x ɣ ts dz l (ɾ) ʎ	• Deletion of close syllable final phoneme within word • Clusters with fricatives and / ɾ / emerge	
STAGE VI (5;0 – 5;6)	m n ɲ p b t d c ɟ k g f v θ ð s z ç ʝ x ɣ ts dz l (ɾ) ʎ	• Deletion of close syllable final phoneme within word • Clusters with three consonants emerge	
STAGE VII (5;6 – 6;0)	m n ɲ p b t d c ɟ k g f v θ ð s z ç ʝ x ɣ ts dz l r ʎ	• Clusters with three consonants are fully acquired in word initial syllable initial position	

[1]

[1] In brackets phonemes emerging at that age but not yet integrated by 75% of children

Up to this point, morphological and phonological characteristics of the Greek language have been presented, as well as the developmental path of language acquisition followed by typically developing Greek speaking children. However, studies investigating the development of phonology provide normative data on the acquisition of certain phonemes and phonotactic structures in spontaneous speech production. There are no data available about speech input processing, nor speech production in repetition tasks. Thus a comprehensive description of the development of speech processing skills for Greek speaking chidren is not yet available. Moreover, these studies investigated the development either of phonology or morphology. None of the studies of typical language acquisition in Greek investigated the development of morphology and phonology in parallel on the same children. In the following section studies on atypical language acquisition in Greek speaking children will be presented. The main aim of this review is to report on features of the language that seem to be most challenging for children. A second aim is to identify cross-linguistic differences observed between Greek speaking children and children who speak other languages such as English in order to enhance understanding of difficulties that arise in language acquisition.

1.5 Studies in Greek speaking children with language difficulties

Studies of Greek-speaking children with language difficulties indicate that the most vulnerable areas are clitic pronouns, definite articles and tense. Initially research in the field focused on single case studies. One of the first studies was conducted by Tsimpli & Stavrakaki (1999). They studied the spontaneous speech of a 5;5 year-old girl who had been diagnosed with specific language impairment (SLI). The participant had significant difficulties with the use of third person accusative object clitic pronouns and definite articles, showing high rates of omission (95%) in obligatory contexts. Tsimpli & Stavrakaki (1999) cite the following sample of Eva's spontaneous speech /ˈvɐziˈ fɐcɛlo/ (*put* $_{2nd\ sing}$ *envelop*) as an example of omission errors in object clitic pronouns that should have been produced as /**to** ˈvɐzis **sto** ˈfɐcɛlo/. In this sample verb suffix *–s* required for the 2nd person in singular is also omitted. Tsimpli & Stavrakaki (1999) cite the following sample of Eva's spontaneous speech /ˈpɛzi poˈtiɾi ɣɐˈtulɐ/ (*play* $_{3rd\ sing}$ *glass kitty*) that should have been produced as /ˈpɛzi mɛ **to** poˈtiɾi **i** ɣɐˈtulɐ/ (*play* $_{3rd\ sing}$ *with the glass the kitty – The kitty plays with the glass*[2]). Higher performance was noted on full pronouns, indefinite articles and other types of clitic pronouns such as genitive possessive clitics in Eva's spontaneous speech.

Diamanti (2000) and Varlokosta (2000) also report impaired object clitics and definite articles in the spontaneous speech of children with SLI. In the studies reported so far there were no typically developing children used as controls and the researchers have compared their participants' performance with data from corpora of typically-developing children involving only four children (e.g. the CHILDES corpus for Greek, Stephany 1997).

Afterwards group studies of spontaneous speech were conducted. In a follow up to the 1999 study Stavrakaki (2001) studied the spontaneous speech of eight older children with SLI (mean age 7;3 years), who seemingly had difficulties with clitic pronouns and definite articles at a younger age. These difficulties were no more observed in their spontaneous language. However, children had difficulty with more complex syntactic structures such as relative clauses and passive voice.

Tsimpli (2001) investigated performance of seven children aged 3;5 to 7;0 years with SLI. Children could accurately mark past tense in the majority of obligatory contexts. However future was not marked consistently, especially regarding the proper use of subjunctive particles (/θɐ/, similar to 'will' in English). SLI children had acquired first and third person of verbs in both numbers. They still exhibited difficulties with the second person; however, overuse of third person form, which has been observed in data from younger typically developing children, was not a characteristic of this set of SLI data. A similar pattern of development was observed for SLI and typically developing children with regard to the types of questions more frequently used i.e. 'what' and 'where' questions. Dissociation was found in SLI children between object clitics and definite articles with the latter being less impaired at a stage where object clitic pronouns still posed difficulties.

Mastropavlou (2006) used elicitation tasks to compare 10 preschool children with SLI aged 4;2 to 5;9 years to typically-developing age and language-matched control groups. There was dissociation between accusative object clitics and genitive possessive clitics. The errors on clitic pronouns in that study consisted of both omissions and substitutions, and the rate of

[2] Recall that Greek is a free word-order language. The syntactic role of words, irrespective of position in the sentence, can be inferred from morphological characteristics.

omissions was not as high as that reported in Tsimpli & Stavrakaki's (1999) study on Eva (30% compared to 95%). Different findings could be attributed to several factors: 1. the first study looked at a small number of children over a wide age range whereas the second study included more participants and the age range was smaller. 2. Data in the first study derived from spontaneous production while in the second study data were collected through elicitation. 3. In the second study performance of children with SLI was compared to typically developing age and language matched controls unlike the first study where no control groups were employed as a means for comparison. Mastropavlou concluded that 'specific language impairment impedes on the acquisition of the morphological expression of formal features rather than their abstract representation, while the different error patterns exhibited by the language-impaired group compared to the two control groups indicate deviant rather than delayed development' (2006, page xiv).

Smith (2009) studied the performance of nine children aged 4;9 to 6;9 years with a diagnosis of SLI in comparison to chronological age (CA) and language age (LA) matched controls in a number of morphosyntactic structures. Elicitation tasks were used to assess (a) third person object clitic pronouns, (b) definite articles, (c) genitive possessive clitics, (d) subject-verb (S-V) agreement, and (e) past tense. In addition phonological short-term memory (PSTM) skills were assessed through a nonword repetition and a digit span task. Object clitics and PSTM skills were areas of exceptional difficulty for children with SLI, on which they differed significantly from both control groups. The participants produced significantly fewer clitics overall and fewer correct forms than both control groups. On the production of definite articles, SLI participants differed significantly from the CA group only. The language impaired group did not differ from any of the control groups on genitive possessives. Within-group comparisons revealed a significantly higher performance on definite articles and on genitive possessives than on accusative and genitive object clitics for the SLI group. Higher performance was also noted on S-V agreement compared to clitics and past tense. Smith (2008) concluded that children with SLI have difficulties both in morphosyntax and in PSTM and that, an additive effect is possible whereby participants with impairment in both factors are at risk for the most severe linguistic impairment.

Mastropavlou (2010) investigated past tense production from Greek speaking children with SLI and control groups matched on age (CA) and language development (LD). As explained in section 1.3 in Greek tense is morphophonologically marked. Different verb stems are used to mark morphologically past tense as opposed to non – past as can be seen in Table 1-1. In addition past tense is marked phonologically through a stress shift to the antepenultimate syllable. The addition of a prefixed syllabic augment is compulsory for verbs with two syllables to accomplish the antepenultimate rule as in the case of present /ˈðɛno/(*tie)* /ˈɛðɛsɐ/ *(tied)* presented in Table 1-1. Syllable augment *ε-* is considered to be the strongest phonological cue. Mastropavlou assessed performance on past tense production on three conditions:

a) Regular verbs requiring either stress shift (low saliency verbs) or stress shift and augment (high saliency verbs)

b) Regular verbs of the previous condition with irregular verbs that do not follow the rules but are rather formed with a fully irregular stem for example present /ˈpino/ *(drink)*→ past /ˈipjɐ/ (*drank*), present /ˈlɛo/ (*say*) →past /ˈipɐ/ (*said*).

c) Pseudo verbs of low saliency and high saliency presented along with real verbs in random order.

Results indicated an effect of saliency for the three groups, as children performed better on high as compared to low saliency verbs. Difference in performance between high and low saliency verbs was significant for SLI and LD controls, but not CA controls. An effect of regularity was also found as all groups of children performed better in the production of irregular as compared to regular verbs. However, the effect was weak as the differences between the two categories (regular – irregular) were only significant for the CA group. For pseudo verbs there was a significant effect of salience for all groups. Performance of the SLI group was significantly lower than the performance of the other two groups in production of low saliency pseudo verbs. Error analysis indicated that typically developing children tended to overextend the augment rule to low saliency verbs whereas SLI children tended to repeat the stimuli instead of producing a past tense form. Mastropavlou suggested that children with SLI differed quantitatively and qualitatively from control groups, indicating that past tense is underspecified for this group of children, whereas phonology seemed to play a facilitatory role in acquisition.

Researchers studying the linguistic characteristics of Greek-speaking children suggest that SLI can be explained by the Interpretability Hypothesis (IH). According to Tsimpli and Stavrakaki (1999) the IH is a linguistic account of SLI as a deficit in linguistic representations. It follows the principles of Minimalism (Chomsky, 1995). It is suggested that there are two levels where language features can either be interpretable or uninterpretable. These two interface levels are the Phonetic Form (PF) and the Logical Form (LF). The Phonetic Form (PF) interferes with features of a purely morphosyntactic function that are represented exclusively in the language system. Logical Form (LF) associates with semantic/conceptual representations. The IH assumes that SLI affects children's ability to acquire grammatical characteristics that are uninterpretable at the semantic/conceptual level LF. The extent to which linguistic characteristics are interpretable determines the extent to which they are accessible to developing grammar. Specifically IH holds that the features associated with semantic/conceptual features of the mental lexicon are interpretable in LF thus have an advantage in order to be mastered. These features have both lexical entry in the language dictionary, and additional semantic representation.

Tsimpli and Mastropavlou (2007) argue that those characteristics that have properties corresponding to the semantic / conceptual level are acquired more readily by children. It is suggested that phonological awareness of grammatical features has an important role for the proper realization of these features to the linguistic expression. It is proposed that phonology acts as compensatory factor to the difficulties observed at the morphosyntactic level. Tsimpli & Stavrakaki (1999) noted that children tend to change the prosodic features of expressions in order to express grammatical features that they are not able to express morpho-syntactically. The phonetic realization of specific characteristics in different languages is considered responsible for cross-linguistic differences in acquisition as for example in the case of Tense (Mastropavlou, 2006).

Mastropavlou (2010) provides evidence that Greek speaking children with SLI perform better than English speaking children on verb inflectional tasks. Greek speaking children as compared to English speaking children exhibit significantly fewer difficulties with past tense morphology, which are attributed to interpretability of grammatical features in PF. For Greek speaking children difficulties in the use of past tense arose when morphophonological salience was reduced; indicating that in Greek the feature of tense is affected by morphophonological salience.

Similarly, data from spontaneous language production (Mastropavlou & Tsimpli, 2011) show lower performance in comprehension and production of complementizers and markers of subordination for children with SLI compared to controls matched on age (CA) and language development (LD).

With regard to the use of /nɐ/ *(to)* that can be used in complement clauses, main clauses and adverbial clauses, a high omission rate was noted in SLI data, rare omission in LD and no omission in CA group. The omission of /nɐ/ in obligatory contexts is illustrated in the following samples:

- Complement clause*ˈθɛlo ˈpɐɾo (*want$_{1sg}$ take$_{1sg}$*) : /ˈθɛlo **nɐ** ˈpɐɾo/ (*want$_{1sg}$ **to** take$_{1sg}$*)
- Main clause *to ˈvɐlis ɛˈci (*it put$_{2s}$ there*) : /**nɐ** to ˈvɐlis ɛˈci/ (*Put$_{2s}$ it there*)
- Purpose adverbial clause * ˈvɐdi to ˈpodi tu to tuˈpitunɛ (*put$_{3s}$ the leg his it wipe$_{3pl}$*): /ˈvɐzi to ˈpoði tu ɛˈci (jɐ) **nɐ** tu to skupisunɛ/ (*put$_{2s}$ his leg there for them **to** wipe$_{3pl}$ it*)

With regard to the use of /ˈoti/, that introduces complement clauses, obligatory contexts in spontaneous production were much fewer for SLI and LD controls compared to AC controls, indicating that /ˈoti/ complements develop later in typical language acquisition. Even in those few obligatory contexts the SLI group had a high omission rate whereas LD controls produced the complementizer accurately in all occasions. The omission of /ˈoti/ in obligatory contexts is illustrated in the following samples:

*ɐˈftos ˈlɛi ponˈɐi (*say $_{3s}$ hurt $_{3s}$*): /ɐˈftos ˈlɛi ˈoti poˈnɐi/ *([he] says that [he] is hurting*)

*ˈksɛɾi θɐ ˈfiji (*know$_{3s}$ will go$_{3s}$*): /ˈksɛɾi ˈoti θɐ ˈfiji/ *([he] knows that [he] will leave*)

It is beyond the scope of this thesis to provide more examples concerning the omission of further complementizers. The differences between the SLI group and the two typically developing groups lie mainly in the omission of complementizers in the context of complement to a verb rather than when used as adverbial clauses. Mastropavlou & Tsimpli (2011) claimed that data provide evidence that categories of low semantic weight within lexicon are more vulnerable for children with SLI. In addition there appears to be difficulty integrating lexical semantics and functional characteristics.

The studies reported so far provide strong evidence of difficulties with the correct use of clitics and tense morphology in Greek speaking children with SLI. However these studies have focused only on production, disregarding perception and phonological properties of the test stimuli. As Greek is a highly inflected language it is relevant to investigate if children can discriminate between morphemes that they do not produce.

It is also interesting to investigate the effect of speech and language therapy on the subsequent development of a child with speech or language difficulties. A careful study of a child's response to intervention can identify areas of speech and language where greater change is observed within a shorter time and thus to highlight areas receptive to intervention, which are expected to result in considerable development of speech and language skills.

Intervention case studies may provide information on theoretical questions for the organization of the speech processing system. For example it may be better understood whether information about the morphological features of a word is included in the verbal representations, or if the stored linguistic knowledge solely contains information about the phonological form and meaning. Whether morphological, phonological and semantic information are integrated in a whole unit or separately stored.

So far studies of Greek speaking children with SLI have been presented, identifying potential clinical markers in Greek. However these studies also raise issues about phonological short term memory (Smith, 2009) and the role of phonology (Mastropavlou, 2006; Mastropavlou & Tsimpli, 2011). The following section considers the influence of such factors on language acquisition.

1.6 Factors influencing language acquisition

1.6.1 Speech perception

Speech perception is thought to influence language acquisition. In the seventies Tallal and Piercy (1973) compared performance of children with SLI to typically developing age and IQ – matched controls on sequencing or temporal judgment and frequency discrimination tasks. Children with SLI were impaired on both tasks in comparison to matched controls when successive stimuli were presented rapidly. This finding was interpreted as a sequencing difficulty and as a basic constraint in the rate of processing that affects multiple levels of acoustic analysis. Tallal & Stark (1981) suggested that children with language learning difficulties have a reduced capacity for processing rapidly successive information.

According to Chiat (2001) there is evidence that impaired phonological processing affects the development not only of phonological knowledge but also of semantics, morphology and syntax. In this account processing of auditory input is essential for the mapping process between those different components through which the words and sentence structure are established. Phonological skills, including speech discrimination and integrity of phonological representations, are correlated with language in children with language difficulties (Chiat, 2001).

Tsao et al (2004) investigated the possibility that infants' early phonetic perception during the first 2 years of life is affecting language development. In their study, speech discrimination was measured in 6-month-old infants using a conditioned head-turn task. At 13, 16, and 24 months of age, language development of these children was assessed. There were significant correlations between speech perception at 6 months of age and later language development as demonstrated by word understanding, word production and phrase understanding. The finding that speech perception performance at 6 months predicts language at 2 years is thought to provide evidence that phonetic perception may play an important role in language acquisition.

Evidence that such a relationship applies to older children as well derives from the research of Edwards, Fox, & Rogers (2002) who showed that the development of vocabulary relates to the ability to discriminate words. Receptive vocabulary size of pre-school aged children was found to correlate significantly with their ability to discriminate CVC words that differed only in the final consonant.

Turning to children with language impairment Corriveau, Pasquini & Goswami (2007) report that the vast majority of children with SLI, assessed in a series of nonspeech auditory processing tasks, performed below the 5th percentile of age-matched controls. These results are interpreted as evidence that the auditory processing difficulties of children with SLI are not limited to brief, rapidly successive acoustic cues, as suggested by Tallal.

Ziegler and collegues (2005; 2009) suggest that speech identification relates to comprehension and production of spoken language. Speech perception difficulties have been proposed to be the cause of language difficulties. Ziegler, Pech-Georgel, George, Alario, & Lorenzi (2005) showed that children with SLI compared to a group of younger, typically developing language matched controls had poorer-than-normal consonant identification under masking noise. Information transmission of all phonetic features (voicing, place, and manner) was impaired, although the deficits were strongest for voicing. Their data indicate that speech identification in noise predicts language impairment to a great extent within the group of children with SLI and across all participants.

In a subsequent study Ziegler, Pech-Georgel, George, & Lorenz (2011) further investigated speech perception of four phonetic categories (voicing, place, manner, and nasality) in children with SLI and age-matched controls in quiet and various noise conditions. In terms of phonetic categories, voicing was more affected than place, manner, or nasality. Speech perception in noise correlated with an oral language component but not with either a memory or IQ component, and it accounted for unique variance beyond IQ and low-level auditory perception. Authors suggested that poor speech perception seems to be one of the primary deficits in children with SLI that might explain poor phonological development, impaired word production, and poor word comprehension.

Difficulties at the level of phoneme identification in nonword discrimination were also reported for Swedish children with SLI. Performance on this task correlated significantly with expressive phonology (Reuterskiöld-Wagner, Sahlén, & Nyman, 2005).

Joanisse and Siedenberg (1998) in a review paper on SLI suggest that there is considerable evidence that SLI is associated with impaired speech processing. They refer to difficulties in discriminating phonological features such as voicing (Elliott, Hammer, & Scholl, 1989;1990) in discriminating, identifying and ordering vowels (Stark & Heinz, 1996), in processing rapid, sequential information (Tallal, 1990; 1996). However they challenge this explanation as they report studies of children with this sort of processing deficits whose language is not impaired (Krauss, Fisher, Plate, Hart, Uematsu, Gordon, & Lesser, 1996). There is conflicting evidence as to whether a perceptual deficit affects some speech sounds or extends to all types of speech contrasts (Joanisse & Seidenberg, 1998). Emphasis is put on the heterogeneity of children with SLI in relation to grammatical impairments and the existence of other perceptual, memory, learning and motoric capacities that may be impaired along with language.

With regard to Greek speaking children, research in speech perception is limited to the field of dyslexia. Panteli (2012) used rapid temporal order judgement, rapid frequency discrimination and p-centre identification to investigate two different explanatory factors for difficulties in phonological processing: a. perception of rapidly presented auditory stimuli (Tallal, 1980) and b. perception of the perceptual centre of acoustic signals (p-centre) (Goswami et al., 2002). A group of children with dyslexia attending the 4th grade were compared to a group of good readers matched on chronological age (attending the 4th grade) and a group of good readers matched on reading age (attending the 2nd grade) on the basis of word and nonword reading accuracy. In tasks of rapid frequency discrimination and p-centre identification, significant differences in performance were observed between a control group matched on reading age (attending the 2nd grade) and the two groups of children attending the 4th grade. There was not a significant difference in performance of children with dyslexia compared to age matched controls. The author suggested that differences in performance observed between the children with dyslexia and control groups in experimental tasks could be attributed to developmental differences rather than differences in reading ability. Results were not supportive of the two hypotheses tested concerning deficits in parameters of perception of acoustic stimuli (Panteli, 2012).

Similar findings, which contradict findings for English speaking children, were reported for older children with dyslexia (Georgiou, Papadopoulos, Zarouna, & Parrila, 2012; Georgiou, Protopapas, Papadopoulos, Skaloumbakas, & Parrila, 2010). Despite the fact that some of the children with dyslexia experienced auditory temporal processing deficits, research studies indicate that Greek children with dyslexia as a group do not perform significantly worse on auditory processing measures than the control groups.

However, differences in characteristics of spoken and written language between Greek and English cannot be ignored. Greek is a syllable – timed language (Arvaniti, 1994) whereas English is a stress – timed language (Ramus, Nespor, & Mehler, 1999). Rhythm and prosody characteristics of the language they are exposed to impact on children from early infancy (Nazzi, Bertoncini, & Mehler, 1998). Therefore, speech perception abilities may follow a different developmental pattern between Greek and English speaking children. The transparent nature of reading in Greek facilitates literacy development (Seymour, Aro, & Erskine, 2003), hence it is possible that this influences the extent to which students rely on acoustic intake.

The studies in speech perception in Greek speaking children that have been conducted to date have included in their clinical sample children who have already been attending school for a few years. As a result it can be expected that these children have acquired spoken language and have developed literacy skills to a certain extent. It could be informative to investigate speech perception in younger children, whilst they are first exposed to literacy instruction as well as in preschool children that are still developing oral language. It is important to know whether there is some involvement of factors relevant to speech input processing in the early stages of morphological development both for the comprehension and production of fine grained morphological distinctions.

1.6.2 Short Term Memory (STM)

Short term memory (STM) 'generally refers to the temporary storage and recall of untransformed material' (Vance, 2008, p. 24). Verbal and visuospatial material is kept for a short time - from a few seconds up to one or two minutes. The temporary storage and rehearsal of acoustic information is enabled through the phonological loop, a phonological short term memory feature of recalling verbal material without processing it (Baddeley, 2000). Working memory (WM) refers to a mental workspace determined to temporarily store and process information, it's a 'processing resource of limited capacity, involved in the preservation of information, that simultaneously processes the same or other information' (Swanson & Sáez, 2003, p. 215). WM relates to our ability to retain information in order to use it in a relevant task. There is an extensive body of literature on the relationship between STM, WM and language development in children with language impairments (Gathercole & Baddeley, 1990; Montgomery, 2000a, b; Bishop et al., 1996) and typically developing children (Adams & Gathercole, 1995; 2000).

Adams & Gathercole (1996) investigated the relationship between phonological working memory and spoken language development in a large unselected sample of 4- and 5-year old children. Their expressive language abilities were assessed using the Bus Story (Renfrew, 1969) and phonological working memory skills were assessed using memory span and nonword repetition. The ability to repeat non-words, which according to the authors reflects PSTM capacity, made a significant contribution to the variance in the children's speech and expressive language performance independently of age, vocabulary knowledge, and nonverbal cognitive skills. It was suggested that skills assessed by phonological memory tasks may be linked to the development of speech production abilities.

The hypothesis that memory is contributing to listening comprehension in preschool age children was investigated by Florit, Roch, Altoe, & Levorato (2009). Two groups of typically developing preschool children (44 children aged 4 years and 40 children aged 5-years-old) were assessed in story comprehension, short-term and working memory skills (indexed by forward and backward word span), verbal intelligence and receptive vocabulary. It was shown that after controlling for verbal abilities, both short-term and working memory predicted listening comprehension. Results also indicate a strong relation between verbal abilities and listening comprehension in 4- and 5-year-old children.

Ellis (1996) argues that working memory is heavily involved in language acquisition as (a) a major part of language learning is the learning of sequences, (b) working memory allows short-term maintenance of sequence information, and (c) short-term rehearsal of sequences promotes the consolidation of long-term memories of language sequences. The studies of Adams and Gathercole (1996) and Florit et al., (2009) provide evidence that in typically developing children language comprehension and production correlate with short term memory measurements to a greater extent than would be expected based on non verbal intelligence and vocabulary knowledge.

Children with SLI typically exhibit poor digit span, and show impairment on nonword repetition (Baddeley et al., 1998; Gathercole & Baddeley, 1990). Children with SLI have difficulty in repeating long nonwords and nonwords containing consonant clusters significantly less accurately than age-matched and language-matched control groups (Archibald & Gathercole, 2006a). Archibald & Gathercole (2006b) investigated the possibility that deficits in immediate verbal short-term memory and working memory may co-occur in a group of children with SLI. A group of 27 language impaired children aged 7-11 years were asked to complete tasks of verbal short term memory such as non-word repetition and digit recall and tasks tapping verbal working memory such as listening recall (judging if a sentence is true and remembering the last word). The majority of the participants had difficulty both in verbal short-term memory and working memory. Difficulties remained even when the general language abilities were taken into account. The authors interpret these findings as evidence of a primary role of memory deficits in developmental language disorder.

There is a well-established word-length effect on short term memory tasks (Baddeley et al., 1998). However, cross linguistic studies indicate that morphological complexity has a large impact on working memory performance. Morphological complexity of stimuli exceeded the impact of stimuli length on working memory performance of Hungarian speaking children with SLI (Marton et al., 2006). Hungarian speaking children with SLI (age: 7;6–10;5, mean: 8;11) performed more poorly than age matched controls (age: 7;6– 10;5, mean: 8;9) in tasks of working memory such as sentence repetition and answering to questions following the presentation of sentences. In comparison to English speaking children with SLI, it was the morphological and syntactic complexity of stimuli rather than the sentence length that affected their performance; qualitative differences in performance suggest that linguistic characteristics of the language tested interfere with working memory performance.

Service & Tujulin (2002) studied the effect of morphological complexity on working memory in list recall tasks with base words (e.g. *boy*), inflected words (*boy + 's*) and derived words (*boy + hood*) in Finnish. 8-year-old normally reading participants, children with dyslexia, and adults without reading difficulties were compared in simple serial recall and complex working memory tasks, combining word recall with sentence verification. The normally reading children performed better than children with dyslexia on both memory tasks and a test of morphology. Base words were better recalled than morphologically complex words. Memory was better for derived than inflected words in simple but not complex span tasks. There was no interaction between word type and reading group and thus no suggestion of dyslexia being associated with specific problems in representing complex morphology in working memory. Morphological processing in working memory appeared to depend on the task. Greek is also a morphologically rich language and it could be anticipated that morphological elements impact on working memory.

There is increasing evidence to suggest that working memory and language learning, including even foreign language learning (Service, 1992), are strongly linked. What remains less clear is why these associations are observed. It is worth noting that the word length of stimuli has been found to have an effect on short term memory task performance (Archibald & Gathercole, 2006a; Baddeley, Gathercole, & Papagno, 1998). However there is controversy about the interpretation of this observation. It has been suggested that the word length effect can influence retention through both rehearsal and output factors, as proposed by the phonological loop hypothesis (Archibald & Gathercole, 2006b). Others have suggested that phonological storage itself is merely a reflection of deeper phonological processing problems (Snowling, Chiat, & Hulme, 1991).

Turning to Greek speaking children, Porpodas (1991) found a direct relationship between the level of phonetic representation held in STM at preschool level and reading achievement at the end of 1st grade. In a subsequent study compared good and poor readers in STM storage and recall of rhyming and non-rhyming strings of words and letters. Irrespective of oral or visual mode of presentation good young readers of Greek outperformed poor readers. The author's concluding remark was that functional difficulties with the articulatory loop of working memory seem to inhibit the learning of reading.

Maridaki-Kassotaki (2002) investigated the effect of training phonological memory in preschool years on subsequent reading achievement in early school years. 120 kindergarten children were randomly assigned to experimental and control conditions. The experimental group received training four days per week for a quarter of an hour on NW Repetition as a method of promoting phonological memory while the control group at the same time was working with handicraft activities. Both groups were assessed on reading achievement at the end of 1st grade. Reading assessment consisted of 30 items, including words or short sentences that had to be read silently. Subsequently children had to act in response to instructions conveyed by the meaning of written stimuli as for example by pointing to a picture or drawing. Subjects trained on NW Repetition in kindergarten performed better than untrained controls in the reading test. Maridaki-Kassotaki (2002) interpreted these data as evidence that training phonological strategies in preschool years augments reading skills during early school years.

Chrysochoou and Bablekou (2011) investigated the relationship between oral story comprehension and working memory and the mediating role of vocabulary. Three groups of children aged 5;5, 7;5 and 9;5 years were assessed on receptive vocabulary and oral comprehension. Five short stories differentiated in (a) length, (b) syntactic structure and (c) grammatical structure were presented, accompanied by questions measuring comprehension elements such as literal and inferential comprehension. Working memory was assessed with four tasks intending to address the phonological loop component: word, NW, and digit recall and word list matching; and three tasks intending to address the central executive component: listening, counting, backward digit recall. Results indicated a significant direct contribution of the central executive to oral comprehension above any vocabulary contribution, despite the variance that verbally mediated WM measures shared with vocabulary. Effects were stronger in preschool years and decreased with age. It is possible that metacognitive skills support older children in comprehension tasks therefore at 7; 5 and 9; 5 years children rely less on WM. For the group of 5; 5 year old children literal comprehension was stronger than inference generation and simile comprehension. It is possible that preschool children rely heavily on WM to attain information and form a coherent representation of the story so that they can only retrieve exact words in order to answer literal questions. It is worth noting that neither adequate WM nor good vocabulary knowledge could fully account for oral comprehension. A significant percentage of oral comprehension variance remained unexplained in regression analyses, suggesting that oral comprehension is closely linked to prior knowledge and expertise.

Chrysochoou, Bablekou, Masoura, and Tsigilis (2013) investigated the relative contributions of verbal STM and WM to vocabulary development in early years in Greek children aged 5; 5

(preschool), 7; 5 (2nd grade), 8; 5 (3rd grade), 9; 5 (4th grade). Children were assessed for receptive vocabulary with an adaptation of the Peabody vocabulary test. Verbal STM was assessed with three serial recall tasks (digit, word and nonword list recall) and WM was assessed with three tasks of parallel storage and processing (listening recall, counting recall and backward recall). Results indicated that vocabulary was solely related to verbal WM in the preschool period. At the age of 7; 5 vocabulary score associated to verbal STM. Both verbal WM and STM made a shared contribution to vocabulary at 8; 5. Associations with vocabulary turned non – significant by 9;5 years, earlier than in English speaking children (Cain, Oakhill, & Bryant, 2004).

Vocabulary development in relation to memory skills in Greek children can shed light on the different requirements posed by the language compared to the English language in which most investigations have been conducted. The correlation between WM but not STM and the development of vocabulary in 5; 5 year old children (Chrysochoou et al., 2013) indicates that young Greek speaking children rely heavily on WM resources to acquire new words. In the real world, in a highly inflectional and derivational language like Greek, children are exposed to new words whose form undergoes considerable variation depending on the grammatical function in specific contexts. Vocabulary development requires that children are able to retain the grammatical form as well as the phonological form and the semantic interpretation in context in an attempt to extract meaning for new lexical items, therefore vocabulary development is facilitated by WM skills.

In contrast to the preschool period, vocabulary development correlated to STM for children at the age of 7; 5 and 8; 5 attending school at the 2nd and 3rd grade respectively. Given that reading skills are developing at this period, it is possible that STM skills are used to facilitate vocabulary development through reading. Association between vocabulary and memory skills declined with age. The relationship between vocabulary knowledge and both STM and WM measurements was not significant by the age of 9;5 for Greek speaking children, earlier than has been observed in English speaking children (Cain et al., 2004).

Chrysochoou et al., (2013) suggest that characteristics and regularities of the Greek language may account for a shorter period during which vocabulary development is related to memory skills. It is likely that as the number of possible syllabic structures in Greek is limited, as presented in section 1.4, this reduces the need for acoustic analysis and phonological storage relatively early for children learning the Greek language. Another possibility is related to reading attainment. Reading acquisition is faster and easier for Greek children due to the transparency of the writing system in Greek, as compared to opaque orthography in English (Seymour et al., 2003). It is likely that by the time children learn to read, written language intervenes with vocabulary development. Finally it is possible that phonological and morphological regularities support children in learning new words. Despite the highly inflectional nature of the language (as presented in section 1.3) in Greek there are very clear rules determining the modifications words undergo. For example, in Greek regular verbs stress shift to the antepenultimate syllable is used for past tense construction. This phonological feature is thought to facilitate the acquisition of morphology and research data indicate that past tense is acquired earlier by Greek compared to English speaking children (see Mastropavlou, 2010, presented in section 1.3). It is possible that acquisition of rules is followed by their application in new vocabulary interpretation, and thus reduces or compensates for the requirements for phonological storage in memory.

According to data from Finnish (Service & Tujulin, 2002) it seems that morphologically complex words are more difficult to be recalled than words without morphological elements. It seems that for Greek children there is a relationship between the development of vocabulary and memory, even though it declines earlier than for English-speaking children (Chrysochoou et al, 2013). It is important to further investigate in Greek-speaking children, who are frequently exposed to morphologically complex words, the possible link between the development of language skills and the retention of information in memory, as well as between the development of speech processing and retention of information in memory.

1.6.3 Phonological Awareness

Phonological awareness i.e. 'children's knowledge of words as comprised of smaller, discernible units' (Gillon, 2004 p. 2) is a strong predictor of children's progress in reading and spelling (Aidinis & Nunes, 2001; Porpodas, 2002). Despite the significance of phonological awareness for the subsequent development of literacy skills, the origins of phonological awareness in preschool children have received little attention (Carroll, Snowling, Hulme, & Stevenson, 2003). It has been argued that during preschool and early school years the developmental course of phonological awareness follows three phases from awareness of syllables to awareness of onsets and rimes and finally to phoneme awareness (Goswami & Bryant, 1990). Gombert (1992) gave a different conceptual categorization of phonological awareness and suggested that phonological awareness is divided into two types: the epilinguistic and the metalinguistic. The first relates to a general sensitivity to the similarities between the sounds of the language and the latter is a conscious awareness of phonological segments between words, usually phonemes.

In line with the theories about the types of phonological awareness, two theoretical positions regarding the developmental origins of the phoneme as a unit for lexical representation and processing have been proposed.

The first one, the accessibility position, proposed by Liberman, Shankweiler, & Liberman (1989), resembles the epilinguistic and metalinguistic types of phonological awareness (Gombert, 1992). According to the accessibility position (Liberman et al., 1989), it is suggested that phonemic segments are preformed units of representation that are present and functional from early infancy. These segments are at least initially available only for speech processing tasks and access to them at a conscious level is not possible until the child has some reading experience. Phonemes do not undergo any substantial change in their nature.

In contrast with the view on the non-developing nature of the phoneme as a unit for lexical representation, a gradual development of the phoneme has been proposed. According to the second, emergent position (Walley, 1993) the phoneme is an emergent unit that develops gradually during childhood. The development of fine-grained segmental representations for lexical items is related to the level of development of the underlying representations. In support of this theory is the finding that some phoneme awareness is present prior to literacy (Chaney, 1992). A model of spoken word recognition known as the Lexical Restructuring Model was proposed by Metsala & Walley (1998). The model links together speech processing, phoneme awareness and reading. The role of vocabulary growth is highlighted as a precursor in prompting the implementation of more fine-grained, segmental representations for lexical items; this restructuring is viewed as an important prerequisite to the explicit segmentation or phoneme awareness skills. However this model does not predict the development of syllable and rime awareness. According to the Lexical Restructuring Model children are thought to represent words in a holistic manner and later on develop the representation of the sounds within words. Given the fact that tasks of PA measure a child's knowledge of the sounds within words, it is hypothesised that this awareness is related to the status of a child's lexical representations.

Support for this hypothesis derives from the research of Sutherland & Gillon (2007) who investigated PA and accuracy of phonological representations in preschool age children with severe speech impairment in comparison to a group of typically developing peers. Children with speech impairment performed significantly worse than controls on mispronunciation judgment tasks. Performance on PA moderately correlated with performance on tasks that reflect on the accuracy of phonological representations. However, there were no statistically significant group differences observed for phoneme segmentation, phoneme deletion and phoneme blending tasks.

Other researchers report that group differences on PA skills were found between four year old children with expressive phonological delays and normally developing peers (Rvachew, Ohberg, Grawburg, & Heyding, 2003). The two groups presented with significant differences in PA, although both groups had age appropriate vocabulary. These findings contradict the hypothesis that vocabulary growth is the main driver of lexical restructuring in the preschool years (Walley, 1993). It is possible that children who have difficulties in articulating certain phonemes may not represent those phonemes accurately in stored word forms, despite the presence of well specified semantic representations as indicated by age appropriate vocabulary knowledge.

Preston, Hull, & Edwards (2013) investigated the possibility that speech error patterns in preschoolers with speech sound disorders predict articulation and phonological awareness outcomes in school years. Children for whom >10% of their speech sound errors were atypical had lower phonological awareness and literacy scores at school age than children who produced <10% atypical errors. Many atypical speech sound errors in preschoolers may be indicative of weak phonological representations, leading to long-term phonological awareness weaknesses.

In addition to the studies of children with speech difficulties phonological awareness has also been investigated in children with SLI. Thatcher (2010) investigated kindergarten, preschool, and first-grade children with typical development or SLI to determine whether there were developmental differences in their phonological awareness abilities (i.e., syllable, onset/rime, and phonemes). Results revealed a significant difference between the two groups on the sound-segmentation tasks. Typically developing children were more effective at segmenting than were children with SLI. The combined data from this study revealed developmental trends in phonological awareness for the typically developing but not for the SLI population.

Research evidence suggests that preschool language abilities correlate with later phonological awareness (Chaney, 1998). However there is a limited body of studies that link individual subskills of language to phonological awareness (Carroll et al., 2003). One of the studies in this field was carried out by Dale, Crain–Thoreson & Robinson (1995). The authors suggested that there was no link between early language development and later phonological development. The mean length of utterance at the age of two was the only measurement that could predict phonological awareness at the age of four and a half years. Subsequent studies by Silven, Niemi, & Voeten (2002) and Farrar, Ashwell, & Maag (2005) have revealed vocabulary development at the age of two as a factor associated with phonological awareness skills such as rhyming comprehension at the age of four. Recently it has been shown that both narrative skills and vocabulary are associated with phonological awareness in preschool children aged 4 – 6 years (Hipfner-Boucher, Milburn, Weitzman, Greenberg, Pelletier, & Girolametto, 2014).

Differences in the characteristics of spoken language are a plausible source of developmental differences that may explain variations in levels of phonological awareness attained (Ziegler & Goswami, 2005). For example Turkish, Greek, and Italian are languages with a simple syllable structure, mainly consonant–vowel [CV], and relatively limited vowel repertoires. In contrast, French and English have quite complex syllable structures with many consonant clusters and larger vowel repertoires. Turkish, Greek, and Italian speaking children show high levels of syllable awareness prior to literacy, whereas French and English speaking children develop lower levels of syllable awareness prior to literacy (Zielgel & Goswami, 2005). Properties of the spoken language (e.g., vowel harmony for pluralisation in Turkish) “force” Turkish children to notice phonemic changes in the spoken language prior to reading.

Studies with Greek speaking children indicate that development of phonological awareness and phonemic sensitivity begins well before the beginning of formal instruction (Aidinis & Nunes, 2001), when children have no letter-sound nor letter-name knowledge (Manolitsis & Tafa, 2011).

A longitudinal investigation of Greek speaking pre – readers from the beginning until the end of kindergarten revealed that children who did not know any letter-names or letter-sounds succeeded in tasks of initial syllable deletion and phoneme segmentation and also performed above chance level in initial phoneme identification task. Phoneme blending was the only task to be dependent on letter knowledge (Manolitsis & Tafa, 2011). According to the authors a possible explanation for the observed correlation between phoneme blending and knowledge of letters is that graphic forms may support children in visualizing the auditory sequence of phonemes that are included in the target word. A substantial development was noted in phonological awareness skills in tasks of initial phoneme identification, phoneme segmentation and blending between the middle and the end of the school year.

A considerable amount of literature provides evidence that in Greek speaking children syllabic awareness is easier than phonemic awareness (Aidinis & Nunes, 2001; Giannetopoulou, 2003; Ioannou, 2010; Papadopoulos, Charalambous, Kanari, & Loizou, 2004; Papadopoulos, Georgiou, & Kendeou, 2009; Porpodas, 1999). Phonemic analysis of initial phonemes seems to be less challenging as compared to final phonemes; shorter words are easier compared to longer words and words where the target segment is stressed as compared to words where the target segment is unstressed. However, word length and stress do not eliminate the effect of level of segmentation i.e. syllable awareness precedes phoneme awareness (Aidinis & Nunes, 2001). According to Nikolopoulos, Goulandris, Hulme, & Snowling (2006) phoneme awareness is a robust longitudinal predictor of reading and spelling in Greek.

A strong relationship between phonological awareness and literacy acquisition in Greek speaking children has been reported in several studies (Aidinis & Nunes, 2001; Ioannou, 2010; Manolitsis & Tafa, 2011; Nikolopoulos et al., 2006; Porpodas, 1999; Porpodas & Palaiothodorou, 1999). Porpodas & Palaiothodorou, (1999) investigated the effect of training phonological awareness on subsequent school attainment. A causal relationship was found between phonological awareness and subsequent literacy acquisition but not maths. The advantage of training phonological awareness that was evident in primary 1st grade however disappeared by the end of primary 3rd grade. Given the polysyllabic nature of Greek language in which most syllables have an open CV of CCV structure, combination of syllabic units seems to be more important for the development of reading (Porpodas, 2006).

Syllable segmentation and blending are fully developed for Greek children from the age of 3;10 while rhyming is still developing (Giannetopoulou, 2003). The relative ease of Greek children to acquire syllabic awareness is probably due to the fact that the syllables correspond to units of articulated speech, making them easily understood and recognizable (Wagner & Torgesen, 1987). It is interesting to note that Greek is a language with a relatively simple syllable structure in which many onsets and rimes are equivalent to single phonemes (Ziegler & Goswami, 2005).

Papadopoulos et al. (2009) made a retrospective analysis of children whose reading – spelling difficulties were recognized in the 1st grade in the direction of phonological awareness (PA) and rapid automatized naming (RAN) data collected since the time of kindergarten. Analysis revealed that the role of PA in discriminating between groups of children in kindergarten was restricted. However significant differences emerged in literacy attainment in 1st grade that associated to kindergarten PA and RAN skills. PA accounted for orthographic choice and word reading accuracy whereas RAN accounted for variance in word and text fluency measures. The authors suggest that phonological deficits were formerly present, but individual differences among children were not evident because there is considerable overlap in these abilities. Papadopoulos et al. (2009) suggest that individual differences regarding the development of linguistic complexity and cognitive skills required for phonological tasks, only become apparent when reading begins. It is claimed that kindergarten children use the phonological representations and manipulate syllabic and phonemic units equally the same, irrespective of the task demands.

Ioannou (2010) investigated the development of phonological awareness in preschool children with speech and/ or language difficulties compared to typically developing preschool peers. Speech sound difficulties whether accompanied by language difficulties or not had a negative effect on children's ability to manipulate phonological units. Participants in the clinical sample performed better on implicit tasks involving matching than in explicit tasks when a spoken response was required. Ioannou (2010) confirmed both in typically and atypically developing children the findings of Aidinis & Nunes (2001) concerning the main effect of segmental position and stress. Initial syllables were easier to recognize than final and stressed segments easier than unstressed. There was also an effect of phonological complexity indicated by better performance in CV compared to CCV phonotactic structure. In particular initial unstressed syllables with consonant clusters were significantly more taxing than stressed ones. According to Aidinis & Nunes (2001) short words and stressed segments are less demanding on memory and attention and are thus more accessible to young children. However, this effect is only valid provided that a syllable is formed by at least two phonemes. An oddity task requiring children to compare similar words and identify those with the same initial phoneme proved to be easier when the initial phoneme was a consonant in CV structure compared to a vowel that constitutes simultaneously a syllable and a phoneme. Data from Ioannou (2010) and Aidinis & Nunes (2001) provide evidence that phonological awareness is not a homogenously developing ability. This raises the question whether it is the number of segments or the type of segments that affects task difficulty. One should bear in mind that the most prominent syllable structure in Greek is the open CV syllable (Porpodas, 2006).

Ioannou (2010) explored the relationships between the development of phonological awareness and speech processing abilities. Mispronunciation detection and auditory discrimination was found to predict syllable matching ability whereas RW and NW repetition, as measured by the percentage of consonants correct, accounted for manipulation of syllables within words. These results could be expected given the fact that the former task requires children to reflect on stored phonological representations whereas the latter depends on motor programming skills to articulate the response. On these grounds it can be suggested that in typically and atypically developing preschool-age Greek speaking children the development of phonological awareness is determined by speech processing skills.

However, the relationship between the development of speech processing skills and phonological awareness in Greek-speaking preschool children has not been studied, nor the relationship between the development of phonological awareness and language skills. It is possible that during the initial stages of development these skills are associated.

1.7 Summary

The rich morphological system of the Greek language may allow the study of factors that affect language development that are difficult to investigate in morphologically simpler languages, such as English.

In Greek pronouns, definite articles and tense (Smith, Edwards, Stojanovik, & Varlokosta, 2008; Tsimpli & Stavrakaki, 1999) appear to be vulnerable areas for children with language difficulties. Researchers (Mastropavlou, 2006) emphasize the importance of phonology, as a *sine qua non* prerequisite for the realization of grammatical features in linguistic expression. Short-term memory (Smith, 2009) is considered to have a key role in the language development of Greek speaking children.

Cross-linguistic studies and data from Greek speaking children suggest that language development is related to factors such as speech perception, short-term memory and phonological awareness.

Speech perception is considered to be associated with disruption in language development (Tallal & Stark, 1981; Chiat, 2001; Stark & Heinz, 1996; Ziegler, Pech-Georgel, George, Alario,

& Lorenzi, 2005). Some researchers (Joanisse & Seidenberg, 1998) suggest that normal language development can coexist with difficulties in other cognitive skills such as memory or learning abilities. Others, consider memory to be fundamental to language development (Baddeley, 2003), both at the level of language comprehension and production (Florit, Roch, Altoe, & Levorato, 2009). Phonological features like word length (Baddeley et al., 1998) and morphological characteristics in morphologically rich languages such as Hungarian (Marton, 2006) and Swedish (Service, 2002), have been found to affect performance in memory tasks. However, it is still being debated whether the difficulties of retaining information arise due to difficulties of rehearsal (Archibald & Gathercole, 2006b) or due to other factors such as phonological processing (Snowling, Chiat, & Hulme, 1991).

Phonological awareness, particularly segmentation, is an area of weakness for children with SLI. Phonological awareness is associated with underlying representations (Sutherland & Gillon, 2007). The development of vocabulary is considered to have a key role in the development of representations. However, differences have been observed at the level of PA development between groups of children with age-appropriate vocabulary development, but who are different in terms of typical or delayed phonological development.

So far, components of language such as morphology and phonology have been described and studies investigating difficulties with the acquisition of each domain have been presented. However, difficulties both with phonology and morphology may co-occur. It is worth noting that according to Rapin and Allen (1987) the most common form of SLI is a receptive/expressive phonologic/syntactic deficit syndrome. One of the child’s most obvious problems is a tendency to speak in short, simplified sentences, with omission of some grammatical features, such as past tense morphology. It is also common to see simplified speech production, for instance, clusters of consonants may be reduced. It appears that phonology relates to morphology and this may be particularly apparent in a morphologically rich language such as Greek, as indicated by the study of Mastropavlou (2010) on simple past tense production.

Chapter 1 provided a description of phonological and morphological characteristics of the Greek language. Studies on typical and atypical language development were presented along with literature on the development of other factors known to be related to language, such as input processing, short term memory and phonological awareness. Chapter 2 focuses on the identification, assessment and intervention delivery for children with speech and language difficulties. Clinical markers for the assessment of language competence, tasks for the assessment of speech processing skills, issues of classification and description of speech difficulties and intervention for children with co-occurring speech and language difficulties will be presented.

Chapter 2. Assessment of speech and language in children

In this chapter, the main assessment tasks used both in research and in everyday clinical practice will be initially depicted. Studies will be reported to highlight the use of these tests for the investigation of children with typical and atypical development of speech and language. Then the psycholinguistic approach to assessment and the concept of a psycholinguistic profile will be considered. This approach is used as a theoretical base for the design of the evaluation battery for this study and interpretation of results in later chapters.

2.1 Clinical markers for identification of language difficulties:

The use of clinical markers in health sciences plays an important role in accurate identification and appropriate intervention. With regard to specific language impairment (SLI) the establishment of clinical markers is important both clinically and scientifically. From the clinical side the children would be recognized promptly and would receive appropriate intervention. From the perspective of research it would be helpful to identify areas of development where children with language impairments differ from typical children. However the attempt to establish clinical markers has proved quite a challenge (Bortolini et al., 2006). The origins of this problem are firstly the heterogeneity observed among children, secondly the changes in the manifestation of language difficulties as a child grows and thirdly differences amongst children who speak different languages. Rice and her collegues (2000; 2003) and Conti-Ramsden, Botting & Faragher (2001) outline the desired characteristics of a clinical marker: it has to clearly differentiate between children with SLI and the typically-developing population and it has to exhibit a high degree of sensitivity and specificity. Sensitivity refers to the degree to which true cases of SLI are correctly identified as language impaired, whereas specificity refers to the extent to which typically developing children are identified as unaffected. Conti-Ramsden, Botting, and Faragher (2001) also state that a clinical marker should be present throughout development and able to identify children with a history of specific language impairment, even if the difficulty seems to be resolved. Such markers seem to be grammatical tasks, nonword repetition and sentence repetition.

2.1.1 Grammatical tasks

The common point of agreement in research on specific language impairment is that children with SLI have difficulties at the level of morphology (Anderson, 2001; Bortolini et al., 2006; Conti-Ramsden, 2003; Conti-Ramsden et al., 2001; Joanisse & Seidenberg, 1998; Rice, Tomblin, Hoffman, Richman, & Marquis, 2004; Rice & Wexler, 1996). The performance of children with SLI is evaluated against data of typically developing children of the same age (Simkin & Conti-Ramsden, 2001) or controls of younger age, matched on language abilities. Children with SLI are disadvantaged significantly in the expression of grammatical morphemes, i.e. the grammatical elements such as inflections and function words, including auxiliary verbs and articles (Leonard, 2000). Because of the significant weaknesses identified in this field, grammatical morphology is becoming a major focus of research in an effort to understand the disorder and find effective methods of diagnosis and intervention.

Rice and colleagues (1996; 1998) are among the pioneers in search of grammatical markers that characterize SLI. They assessed three groups of preschool children in a set of morphemes that mark Tense in English: a group of children with SLI, a group of children with the same mean length of utterance and a group of children with the same age. The set consisted of: -s third person singular, -ed regular past, and the auxiliaries Be and Do. Results revealed that children with SLI had lower performance than both control groups in the target morphemes; the difficulty found in these morphemes that indicate Tense, did not apply to unbound morphemes such as prepositions; the performance of the groups took the form of bimodal distribution, as children with SLI had low levels of performance, while typically developing peers had high levels of performance equivalent to the performance of adults. From such evidence, it was concluded that the particular set of morphemes that mark Tense can be considered a clinical marker (Rice & Wexler, 1996).

These initial findings were succeeded by a longitudinal study. It was established that typically developing children do not acquire this set of morphemes until the age of 4 years whereas children with SLI not until 7 years (Rice, Wexler, & Hershberger, 1998). Afterwards it was shown that tense-marking limitations apply to appropriate use of irregular past tense. Specifically, children with SLI have difficulty with the morphosyntactic component of irregular past tense (i.e., knowing that past tense contexts require the use of a past tense form) whereas in the morphophonological component (i.e. understanding of the phonological structure of regular and irregular past tense morphology) performance is analogous to that of typically developing younger children (Rice, Wexler, Marquis, & Hershberger, 2000).

Proper use of morphemes marking Tense, as described in the previous investigations, is considered by these researchers to be a skill developing at a slow pace, until the age of four years in typical acquisition. During that period, defined as the *Optional Infinitive* stage, the morphemes are expected sometimes to be used correctly and sometimes to be omitted. Children with SLI take a longer time, not before the age of seven, to overcome this stage of immature grammar. On these grounds, the difficulties encountered by children with SLI in the proper use of morphemes: -s third person singular, -ed regular past, irregular past and the auxiliaries Be and Do are attributed to an *Extended Optional Infinitive* stage, when grammatical representation of tense features is only partially defined (Rice, Noll, & Grimm, 1997).

Although Rice et al. (1998; 2000) suggest that children with SLI have difficulty in forming regular past tense endings in –ed, Blake et al.(2004) claim that this applies only to irregular past tense. Blake et al. (2004) studied the spontaneous speech samples of children with SLI ranging in age from 5;1 to 9;8 years and children matched on age and expressive language abilities and noted that children with SLI did not differ from the other two groups in the mean length of utterance and the use of regular past tense, whereas they performed lower than the typically developing control groups in the correct use of irregular forms. This difficulty was attributed to limited memory capacity. It was claimed that restricted auditory memory makes it difficult for children with SLI to remember irregular past tense forms; therefore production of these forms is significantly limited in comparison to age matched controls. Mastropavlou (2010) found that Greek children with SLI performed better in the production of irregular as compared to regular verbs, but this difference was not significant.

In line with Rice and Wexler (1996) are the findings of Marchman, Wulfeck, and Weismer (1999) that children with SLI exhibit significantly more errors than typically developing age matched controls. Specifically, difficulty with inflectional morphology was evident in the absence of suffixes and the extended use of bare stems. However, the overuse of unmarked grammatical forms was not attributed to an *Extended Optional Infinitive* stage but was rather attributed to surface level phonology and the features of the verb stem. In addition Conti-Ramsden et al. (2001) report that the past tense task is an excellent marker at identifying children with severe language impairment at the age of 11 years. Furthermore, Redmond (2005) found that typically developing children and children with attention deficit hyperactivity disorder (ADHD) made proper use of past tense, while children with SLI produced fewer correct types, of both regular and irregular verbs.

It is important to mention that the study of Blake et al. (2004) is the only one in which the findings are based on a sample of spontaneous speech, while the remaining studies used elicitation of past tense. It is possible that differences in findings are due to the different methods of data collection. In spontaneous speech, a child can choose how to express himself within its language abilities. In contrast, elicitation can be an extremely demanding process, which may target productions beyond the potential of a child and thus highlight weaknesses.

The studies presented so far refer to English speaking children. Although it is accepted that in any language children with SLI have difficulties in inflectional morphology, it cannot be assumed that the same morphemes are susceptible cross linguistically.

Although the 3rd person singular has been identified as a clinical marker in English (Conti-Ramsden et al., 2001; Rice & Wexler, 1996) in Italian it is the 3rd person plural that has been proposed to discriminate between children with SLI and age and language matched controls (Bortolini et al., 2006; Dispaldro, Leonard, & Deevy, 2013a). In fact, the 3rd person plural, as an incorrect language production in children with SLI, is replaced by the corresponding 3rd person singular form. The use of the third instead of the first person of verbs, as well as substitutions and omissions of articles and clitics were reported as weaknesses for Spanish speaking children with SLI (Bedore & Leonard, 2001; 2005). In these cases inflected forms are substituted by another form that shares most, but not all, of the appropriate tense features. It has been suggested that children learning languages with a rich morphological system have an advantage compared to children whose language has a limited morphological system. This is manifested by the fact that in the former case, the children are more likely to use the correct endings in obligatory contexts (Leonard, 2000).

Besides inaccurate use of tense morphology, researchers report on problematic establishment of grammatical agreement. Difficulties with adjective agreement have been reported for noun-related inflectional morphology of Spanish speaking children with SLI (Bedore & Leonard, 2001). Using the appropriate morphemes in order to establish agreement for subject - verb (SVA) has proved quite challenging for children with SLI speaking German (Clahsen, Bartke, & Göllner, 1997; Rothweiler & Clahsen, 1993) and Greek (Clahsen & Dalalakis, 1999). Despite the fact that SVA morphology is significantly affected in SLI, participle morphology is not impaired.

The production of direct object clitics is significantly problematic for children with SLI whose native language is Spanish (Bedore & Leonard, 2001, 2005), Italian (Bortolini et al., 2006; Dispaldro et al., 2013a), Greek (Smith, Edwards, Stojanovik, & Varlokosta, 2008) and French (Jakubowicz, Nash, Rigaut, & Gerard, 1998; Paradis & Crago, 2001). It has been proposed that production of direct object clitics is so vulnerable because of their prosodic position. These morphemes are monosyllabic, weak and found in sentence internal position (Leonard, 2000). However Jakubowicz et al. (1998) challenge this view. Their findings of French speaking children with SLI are considered not to present an overall impairment with function words or a general deficit in phonological processing of weak syllables. Instead, it is argued that children remain sensitive to the main difference between determiners and clitic pronouns. Accuracy of production of nominal and clitic object pronouns (reflexive and accusative) differs depending on the category and the structural properties of the target.

2.1.2 Nonword repetition

There is extensive literature on the development, use and interpretation of nonword repetition tasks. Nonword repetition is a task in which children hear a nonsense word and repeat it immediately afterward. Each sequence does not correspond to a real word but the consonant – vowel combinations within the non-word follow the phonological structure of the language in order to use legal nonwords (Bortolini et al., 2006). Unlike real word repetition, performance on a nonword repetition task is thought not to be influenced by lexical / semantic knowledge, but rather depend on speech processing (Campbell et al., 1997).

Research in the field of nonword repetition briefly addresses two focal points. The first is to diagnose individuals with language difficulties, from different social backgrounds without the involvement of confounding variables related to language assessment such as level of educational attainment, vocabulary or dialect. The second is to inform theories of language acquisition. Nonword repetition tasks have been extensively used in research on typical and atypical language development, in order to elucidate understanding of the underlying processes of language development and to identify the causes of its disruption. Although there is widespread acceptance of the use of nonwords to identify individuals with language difficulties both in English speaking children (Bishop, North & Donlan, 1996; Botting & Conti-Ramsden, 2001; Chiat & Roy, 2007; Conti-Ramsden, 2003; Conti-Ramsden et al., 2001;

Horohov & Oetting, 2004) and in other languages, such as Italian (Bortolini et al., 2006; Dispaldro, Leonard, & Deevy, 2013b), Swedish (Reuterskiöld-Wagner, Sahlén, & Nyman, 2005) and Czech (Smolik & Vavru, 2014), discussion continues about the skills involved and the mechanisms activated during nonword repetition.

In typically developing children nonword repetition has been found to correlate with measures of phonological memory such as digit span and with receptive vocabulary (Gathercole & Baddeley, 1989). A significant correlation between nonword repetition accuracy and receptive vocabulary development was further confirmed (Gathercole & Adams, 1993; Metsala, 1999). The demonstrated link between nonword repetition and language learning generated great interest in the mechanisms involved in the repetition of nonwords. Children with specific language impairment have consistently been found to repeat nonwords significantly less accurately than typically developing age or language matched controls (Gathercole & Baddeley, 1990; James et al. 1994; Ellis Weismer et al., 2000; Conti – Ramsden & Hesketh, 2003). Nevertheless the nature of the skills tapped by the task is still strongly debated.

Non-word repetition has been considered to be a pure measure of phonological short term memory capacity (Gathercole & Baddeley, 1989, 1993). In order to repeat nonwords children have to retain novel phonological information in memory (Baddeley, Gathercole, & Papagno, 1998), such that restricted capacity impacts in decreasing non-word repetition accuracy. Difficulties with nonword repetition were originally attributed to limitations in the capacity of phonological store and/ or atypical rapid decay of items in memory (Gathercole & Baddeley, 1990). A significant difference in non-word repetition accuracy was found between children with SLI and language matched controls, with larger group differences for longer (three and four syllables in length) non-words (Gathercole & Baddeley, 1990; Montgomery, 1995). The word length effect was interpreted as a manifestation of limitations in phonological memory capacity. According to Gathercole (2006) the role of phonological short term memory in nonword repetition is fundamental, so that nonword repetition performance accuracy is reduced if a child is not able to store phonological information in the short term.

However, this view has been strongly questioned by Snowling et al. (1991) who argued that increasing the length of nonwords simultaneously increases the requirements for phonological processes such as segmentation and assembly of articulatory motor programs. According to their view limited memory capacity cannot be considered as sufficient origin of difficulty for the repetition of lengthy nonwords. In addition they challenged the estimation that performance in repetition of nonwords is independent of linguistic knowledge. They rather argued that knowledge of morphological, phonological and prosodic rules is involved in order to facilitate nonword repetition.

Evidence for the impact of existing linguistic knowledge on nonword repetition emerges from a number of studies that demonstrate increased accuracy of nonword repetition as a result of nonword similarities to real words or real word elements. Typically developing children repeat more word-like nonwords significantly better than less word-like nonwords (Gathercole et al. 1991; 1995). Nonword repetition accuracy increases as a result of the manipulation of the lexical status of the stressed syllable (Dollaghan et al. 1993; 1995). Typically developing boys exhibited an apparent lexical effect in the repetition of nonwords whose stressed syllable corresponded to a real word. Typically developing children by the age of two and a half years perform more accurately during imitation of nonwords when phonemes and phonotactic structures of high frequency are included (Coady & Aslin, 2004).

Coady et. al. (2010) investigated the role of phonotactic frequency in nonword repetition by children with SLI. Effect of phonotactic frequency on performance was equivalent for both children with SLI (mean age 9;2) and controls (mean age 8;10) with more accurate repetition of high frequency phonotactic patterns. It is worth noting that sensitivity to phonotactic frequency effect has been confirmed for typically developing children at an early age, whereas participants in this study ranged in age from 7;3 to 10;6 years. It cannot be assumed that younger children with SLI are extracting linguistic regularities in the same way that typically developing children do.

Casalini et al. (2007) provided evidence of an increase in lexical effect on nonword repetition from preschool to school age Italian children. They tested two groups of preschool and school aged Italian children affected by three different subtypes of SLI and typically developing controls in repetition of i) words (W), ii) nonwords consisting of combinations of Italian roots and affixes (MNW) and iii) non-words with no morphological constituents (NW). Children with SLI as a group performed less accurately than controls, however the pattern of performance was similar (repetition of words was better than nonwords and repetition of nonwords with morphological constituents was better than simple nonwords. The influence of lexical and morphological elements on nonword repetition accuracy increased with age among the three SLI subtypes. It was supported that morpho-lexical effects on NWR increase with age. However, the study was based on a cross sectional and not longitudinal design, therefore findings need to be interpreted with caution.

Lexical and sublexical knowledge may impact on children's performance. Archibald and Gathercole (2006a) conclude that findings from an increasing number of nonword repetition studies "cannot be readily accommodated by a verbal short-term memory deficit account of specific language impairment" (p. 979).

The principal role of phonological short term memory in nonword repetition has been further challenged by Estes et al. (2007) on the basis that even for monosyllabic nonwords, there is a significant difference in repetition accuracy between children with SLI and typically developing peers. While group differences are more evident for longer nonwords, inaccurate repetition of monosyllabic nonwords could be associated with difficulties in discrimination, encoding and/ or production demands of the task, rather than with limitations in phonological short term memory.

Subsequent research data are compatible with the view that repetition of nonwords may be affected by difficulties in discrimination. Reuterskiöld-Wagner et al. (2005) demonstrated a significant correlation between repetition of nonwords and discrimination of nonword pairs differentiated by one phoneme. This relation was applicable both to children with typical language development, and children with language impairment, irrespective of coexistence of a speech difficulty. Vance et al. (1999) provided evidence that nonword repetition correlates with mispronunciation detection and picture naming i.e. tasks that tap into input and output processing abilities.

Edwards & Lahey (1998) did not find evidence of auditory discrimination differences between children with SLI and controls. Nevertheless analyzing the number and type of errors in addition to latency and duration of response indicated that children with SLI have difficulty in forming representations rather than in holding phonological information in working memory.

The degree to which nonword repetition is taxing on phonological short term memory may be language dependent. Evidence from Cantonese speaking children indicates that children with SLI could repeat nonwords just as well as their typically developing age matched controls and better than typically developing younger children (Stokes et al., 2006). This is the only study reporting similar performance of typically developing and Children with SLI on nonword repetition. The relatively simple CV structure of Cantonese is a potential explanation for this finding. Performance of English speaking children could be affected by prosodic (temporal and sequential) properties of the task.

According to Bortolini et al., (2006) Italian speaking children with SLI encountered significant difficulty with non-final weak syllables in nonword repetition in comparison to typically developing age matched controls. Nevertheless the effect of nonword length (ranging from one to four syllables) was similar for both groups. It was suggested that prosodic limitations in addition to phonological memory limitations could be part of the SLI profile in Italian. Pointing in the same direction are the findings of Dispaldro (2014) that Italian children with SLI delete weak syllables in a pre-stress position in NW repetition.

The possible effect of articulation skills and motor planning in the repetition of nonwords has been addressed by researchers. To explore this possibility Gathercole et al. (1991) investigated the role of consonant clusters in nonword repetition. It was hypothesised that the presence or absence of consonant clusters in nonword items comprises a difference in articulatory complexity. They found no significant effect of the existence of clusters in nonword repetition accuracy for typically developing children aged 4 - 5. On this basis they argued that phonological memory and not articulatory complexity affects performance on nonword repetition tasks. However, in a subsequent study Gathercole (1995) found a significant correlation between number of consonant clusters within non-words and repetition accuracy. The same effect of articulatory complexity, as defined by the existence of a consonant cluster in a nonword, was found by Bishop et al. (1996).

It has been suggested that production limitations may contribute to differences between groups in nonword repetition (Shriberg et al. 2009). Further studies provide evidence on the relationship between nonword repetition and output processing abilities. Performance in nonword repetition has been assessed in relation to volitional oral movements (VOM) (Stark & Blackwell, 1997). Children with language impairment and children with both language and speech impairment were compared to typically developing age matched controls. Both groups of children with language impairment had greater difficulty than controls with VOM and for both groups nonword repetition accuracy significantly correlated with accuracy/ coordination scores on oral movement tasks. In a recent study movement of articulators in real word and nonword repetition was compared (Reuterskiöld & Grigos, 2015). Results indicated that nonword repetition requires significantly longer duration for the movement of jaw. This effect was particularly evident in younger (mean age 6.10) compared to older (mean age 14.4) participants. These findings suggest that duration of articulators' movement increases during tasks with greater PSTM demands.

A significant correlation was found between expressive phonology and nonword repetition for Swedish speaking children with language impairment (Reuterskiöld-Wagner et al., 2005). This relationship was not applicable to typically developing controls. Hence expressive phonology could account for difficulties with nonword repetition of SLI participants.

Nonword repetition is a controversial measure, with much of the debate focusing on interpretations of the underlying mechanisms that drive children's ability to complete this task. Among the range of possible factors, the role of memory seems to be undisputed. 'Although nonword tasks are likely to be influenced by other types of knowledge, there is agreement that it does tap, at least partly, PSTM abilities, (Hesketh & Conti-Ramsden, 2013, p.2) However, it may be the multifarious nature of the test that makes it such an important clinical marker. As it has been stated by Coady (2008, p.33) in a review of the existing literature, nonword repetition 'taps so many underlying skills that are problematic for children with SLI, it does make a good diagnostic tool'.

2.1.3 Sentence repetition

Sentence repetition has been suggested as a clinical marker, suitable for the identification of children with language difficulties. The task, also referred in the literature as sentence recall, includes the verbal presentation of word sequences that form sentences, usually of increasing length and complexity and requires children to repeat promptly after presentation. It is a readily administered task that allows targeting of specific structures. Performance in direct repetition of sentences is much better than performance in direct serial repetition of syntactically unrelated word lists, indicating that the language processing system is involved in sentence repetition (Willis & Gathercole, 2001).

Seeff-Gabriel, Chiat, and Dodd (2010) highlight that sentence repetition enables the comprehensive evaluation of language competence and language difficulty for a number of reasons. The task allows the examination of a range of targets that may not be easily elicited in spontaneous production, such as negative and question structures. Manipulation of sentence length and syntactic complexity provides valuable information on the child's sentence production abilities. Furthermore, under the time pressure in clinical settings sentence repetition may be more effective than assessment of spontaneous production as it requires a shorter administration. The final benefit of major importance is that sentence repetition enables the objective assessment of language production of children whose speech is unintelligible. During spontaneous sentence production, unlike imitation, the listener is not aware of the word types and syntactic structure targeted by the child and as a result is not always able to determine the accuracy of expressive language.

Sentence repetition has been used as an assessment of children's language skills with various clinical and research objectives. The task has been used to identify surface linguistic errors and investigate the potentially associated loci of impairment, so as to inform theories of typical and atypical language development (Conti-Ramsden, Botting, & Faragher, 2001). In addition it has been used to diagnose children with specific language impairment by differentiating them from typically developing children and children with other types of language difficulties.

Sentence repetition was initially proposed as a clinical marker of SLI by Conti-Ramsden et al. (2001). Currently there is widespread acceptance of its value as a clinical marker in discriminating between children with SLI and typically developing children (Archibald & Joanisse, 2009; Petruccelli, Bavin, & Bretherton, 2012; Riches, 2012; Smolik & Vavru, 2014; Stokes, Wong, Fletcher, & Leonard, 2006). Additionally, sentence repetition has proved sensitive in discriminating between different types of language difficulties such as Auditory Processing Disorders (APD) with or without language impairment (Kiese-Himmel, 2010), SLI and Attention-Deficit/Hyperactivity Disorder (ADHD) and in identifying SLI in bilingual children (Ziethe, Eysholdt, & Doellinger, 2013).

Performance in sentence repetition has been argued to reflect the capacity of PSTM (Willis & Gathercole, 2001). Other groups of researchers dispute the role of memory and suggest that sentence repetition depends on the adequacy of linguistic components (Devescovi & Caselli, 2007; Smolik & Vavru, 2014). Between these two opposing theories is the view that restricted sentence repetition is caused by deficiencies both on memory and on specific language components (Conti-Ramsden et al., 2001).

Memory

Willis and Gathercole (2001) conducted two experiments to investigate the extent to which sentence repetition depends on phonological memory in young children, at the age of four and five years. At this age, both the capacity of phonological memory as well as the syntactic and semantic analysis of sentences is still developing.

The first experiment involved the repetition and comprehension of sentences that differed in length and syntactic complexity. Repetition of sentences containing short words was significantly more accurate than repetition of sentences containing longer words. However, there was no length effect on comprehension of these sentences. The authors interpret this unilateral effect of length in the repetition and not in the comprehension, as evidence that phonological short term memory mediates the repetition of sentences.

The second experiment further investigated sentence processing performance in repetition and production. Participants were divided into two groups, one of high and one of low score in the assessment of phonological memory, according to their performance on the Children's Test of Nonword Repetition (Gathercole and Baddeley, 1996) and auditory digit span (Gathercole, 1995). The group having high phonological short term memory skills scored significantly better in sentence repetition, but there was no significant difference between groups in sentence comprehension. These results were considered as additional evidence that phonological memory affects repetition but not comprehension. However this interpretation is questionable. Since the separation of the groups was based on performance in nonword repetition, it could be expected that difficulties underlying nonword repetition performance for the low score group would be at the root of reduced sentence repetition accuracy. For instance, if speech production difficulties equally affect both tasks, significant difference in sentence repetition performance between the two groups could be artificial. In addition, even if nonword repetition is nothing but a pure phonological memory measurement, it cannot be assumed that the two groups are closely matched on language abilities. Vocabulary acquisition has been found to correlate significantly with nonword repetition. It is possible that participants with low scores in phonological memory would also have restricted vocabulary knowledge in comparison to participants in the high score group. Vocabulary could be a variable affecting sentence repetition performance between the two groups. The word length effect could be attributed to variation in other domains of ability.

To the authors' surprise in both experiments dissociation was observed between repetition and comprehension as a result of manipulation of the sentence type. A pattern of high repetition but relatively low comprehension scores was observed for sentences containing the adverbs *above* and *below* and *vice versa* for sentences containing relative clauses. This finding was evaluated as evidence that comprehension accuracy depends on the level of syntactic development whereas repetition accuracy depends on phonological memory.

Within the phonological short term memory account, repetition is considered to be sensitive to an increase in sentence length as in the case of relative clauses.

Language

However, Seeff-Gabriel et al. (2010) argued that morphosyntactic abilities affect sentence repetition performance. They report that in sentence repetition task children with SLI presented higher incidence of errors in word endings and function words than in content words.

Additional challenge on the role of phonological memory in sentence repetition is derived from Devescovi and Caselli (2007). Sentence repetition was investigated in relation to short term memory and spontaneous speech, to explore the potential role of memory in language skills. Initially the efficacy of the Sentence Repetition Task (SRT) in tracking developmental changes was evaluated. Italian typically developing children between 2;0 and 4;0 years of age were assessed in repetition of sentences with different length and syntactic complexity. This experiment showed considerable group differences and improvement in performance depending on age. At the age of two children tend to omit a large proportion of words from the target sentences resulting in telegraphic sentence repetition. Between the age of 2;0 – 2;6 years there is a decline in the number of word deletions thus increasing the mean length of utterance (MLU). By the age of 3;0 years onwards free function words are barely omitted. The developmental pattern is compatible with literature on language production in the same age range for Italian speaking children.

Once the content validity of the test was confirmed authors investigated links in performance on SRT, spontaneous speech and verbal memory span. Results indicated that MLU, omission of articles and use of verbs in SRT correlated with the same measures of spontaneous language production. This provides evidence that performance in sentence repetition reflects sentence production in free speech. In addition verbal memory span correlated with performance of both the repetition task and free speech. However, when age was taken into account as a factor, verbal memory span did not correlate with the complexity of sentences produced either in spontaneous speech or in repetition. This provides evidence against phonological short term memory involvement in language skills.

Support on the association between language skills and sentence repetition comes from the work of Stokes et al. (2006) with Cantonese speaking children. Sentence repetition was a powerful clinical marker in discriminating between children with SLI and typically developing children of the same age. Even though there was not a significant difference in nonword repetition between the two groups, there was significant difference in sentence repetition between children with SLI and typically developing age matched controls. This difference in sentence repetition was not applicable between children with SLI and younger typically developing language matched controls. Children with similar MLU do not differ significantly in their repetition of sentences regardless of age. This confirms cross linguistically the findings of Devescovi & Caselli (2007) that MLU and sentence repetition are related.

In addition to the previous findings Smolik and Vavru (2014) investigated sentence repetition in Czech children with SLI in comparison with two control groups matched on age and language ability. Scoring of sentence repetition was made with respect to repetition accuracy and error types, including scoring for particular part-of-speech categories. The children were also assessed for receptive vocabulary, digit span and nonword repetition. Children with SLI performed significantly less accurately than controls in sentence repetition, lower than could be accounted by differences in memory measures. However, difference in memory measures could account for difference in sentence repetition performance between the two control groups of typically developing children. It is worth noting that inaccurate sentence repetitions for children with SLI consisted to a great extent of grammatical errors, in particular affecting verbs and clitics. Impairment at the level of syntactic representations is considered a plausible explanation for this pattern.

In addition to syntactic representations the role of phonological processing in sentence repetition for typically developing children and children with SLI has also been explored by Coady, Evans & Kluender (2010). To investigate phonotactic sensitivity in sentence repetition researchers used sentences which contained target words differentiated by the frequency of phonotactic pattern and the position of the word in the sentence. Although children with SLI were significantly less accurate than controls in repetition accuracy, both groups were equally affected by the phonotactic pattern frequency. These results were interpreted as '*evidence that phonological knowledge extracted from across their lexicon can be used to support ... sentence repetition by children with and without SLI*' (Coady et al., 2010: p.1410).

Multi faceted task

Sentence repetition has been proposed to be more taxing on phonological short term memory for children with SLI than for typically developing children (Riches, 2012). Children with SLI, age and language matched controls were assessed in sentence repetition, syntactic knowledge using a structural priming task, working memory and phonological short term memory using delayed repetition of sentences. Children with SLI made more errors than controls in repetition and these errors were qualitatively similar to their errors on other production tasks, indicating that underlying syntactic representation could give rise to these errors. Children with SLI may have difficulty with 'Redintegration' i.e. the use of long-term representation to support maintenance of information in short term memory for repetition. In children with SLI all assessments, including phonological STM were good predictors, suggesting that syntactic knowledge, working memory and short term memory may be equally involved in processing sentences for imitation. In control groups phonological STM was a poor predictor whereas working memory tasks were the strongest predictors. This could indicate that, for children with SLI compared with typically developing children, phonological memory has a distinctive role in sentence repetition.

In agreement with Riches (2012) are the findings of Hesketh and Conti-Ramsden (2013) who explored the role of phonological memory and grammatical morphology in sentence repetition for 11-year-old children with a history of SLI and typically developing children. Participants with a history of SLI had significantly lower performance in sentence repetition than the control group. This difficulty in sentence repetition is applicable even in the case of children with a history of language difficulty that seems resolved, as these children's performance on language comprehension is within normal range. Grammatical knowledge was found to predict significantly performance in sentence repetition both for children with and without a history of SLI. However, predictability of sentence repetition performance from PSTM score was restricted to children with a history of SLI. Apparently grammatical knowledge affects sentence repetition for both groups of children. However, it seems that for children with typical development, dependence on phonological memory decreases over time and the impact of morphological knowledge increases. This is not applicable to children with a history of SLI who still rely on phonological memory. A possible explanation could be that morphological knowledge has not developed to such an extent as to be on its own sufficient to support sentence repetition.

A range of research (Conti-Ramsden et al., 2001; Hesketh & Conti-Ramsden, 2013; Marshall & Nation, 2003; Riches, 2012) suggests that sentence repetition is a complex task that incorporates a number of cognitive and linguistic factors. Difficulties in sentence repetition can be attributed to limitations both in memory as well as in grammatical and semantic abilities.

2.2 Speech processing skills and the psycholinguistic approach

2.2.1 Overview of speech processing and the psycholinguistic approach

Up to this point a number of clinical markers and assessments related to language have been presented. However, it is clear that language skills are not isolated from speaking abilities. For example, nonword and sentence repetition, as well as expressive language tests, involve speech. Indeed, some researchers aim to eliminate the confound of speech difficulty in repetition performance by giving a graded scoring or choosing early developing phonemes (Shriberg et al., 2009). Moreover, speech disorders and language difficulties sometimes co-occur in children (Broomfield & Dodd, 2004b; Shriberg, Tomblin, & McSweeny, 1999). Language tests describe in detail the surface features of the linguistic production. However, it is important to evaluate the language and speech of a child in relation to the underlying cognitive linguistic abilities (Dodd, 2014).

Adopting a psycholinguistic approach, as compared to a corpus approach of language development allows the researcher to manipulate task characteristics and stimuli used in order to investigate not only the final linguistic output but also the processes that may occur during comprehension and production of speech.

In order to investigate in depth how different cognitive abilities (such as short term memory), speech processing abilities (such as auditory perception) and linguistic abilities (such as comprehension and production of past tense, direct object clitics) link together a psycholinguistic approach is required. Psycholinguistic models analyze the speech processing system in its constituent components in order to identify loci of breakdown in the speech processing chain.

Cognitive neuroscience models developed for adults (Levelt, Roelofs, & Meyer, 1999; Dell, Schwartz, Martin, Saffran, & Gagnon, 1997; Caramazza, 1997) would not be appropriate for the investigation of the dynamic, continuously developing system of children. Adult models aim to describe speech and language processing within a well established and mature system in healthy adults or within a damaged, formerly intact system, following an acquired impairment. In the case of children one has to account for brain plasticity and the progressive development of various skills at multiple levels simultaneously (Karmiloff-Smith, 1997). The focal point of interest is on how children gradually acquire new skills to the final development of an integrated system resembling that of adults. It is essential to identify not only the novel skills (for example vocabulary growth, the production of consonant clusters) but also the instance when these skills arise and the processes involved in development (Stackhouse & Wells, 1997). In the case of children with speech and/ or language difficulties consideration must be given to the skills that have not yet developed as expected as well as to underlying processes that may be involved to the difficulty.

According to Baker, Croot, McLeod, and Paul (2001) 'Psycholinguistic approaches to speech and language development aim to explicate the way in which children process speech and language at a cognitive or psychological level and thus aim to formulate hypotheses about the psychological processes or components that may be impaired' (p. 686). Various models have been suggested that differ in the levels and processes proposed (Hewlett, 1990; Dodd, 1995; Stackhouse and Wells, 1997; Hewlett, Gibbon & Cohen-McKenzie, 1998; Chiat, 2000). It is suggested that speech processing includes input processing, output processing and underlying representations of linguistic knowledge. One of the leading models in the field is the psycholinguistic model of Stackhouse and Wells (1997). Baker et al. (2001) suggest that this particular model 'can provide more comprehensive data: data that allow hypothesis testing about the possible problems underlying individual clients' speech and literacy difficulties' (p.692).

2.2.2 The Stackhouse & Wells (1997) psycholinguistic framework

The model follows the principle that typical speech development is based on a speech processing system operating normally. The system develops gradually following five phases: (1) pre-lexical phase, (2) whole word phase, (3) systematic simplification phase, (4) assembly phase and (5) metaphonological phase. The model can be used for studying typical development and disorders of spoken and written language. Speech sound disorders arise from impairment in one or multiple components of the speech processing system. Intervention should target the loci of impairment for each individual child. The model can be used to identify which levels in the speech processing system give rise to a child's speech difficulties (Stackhouse and Wells 2001). This kind of investigation involves comparing performance across more than one test. The model is depicted in figure 2.1.

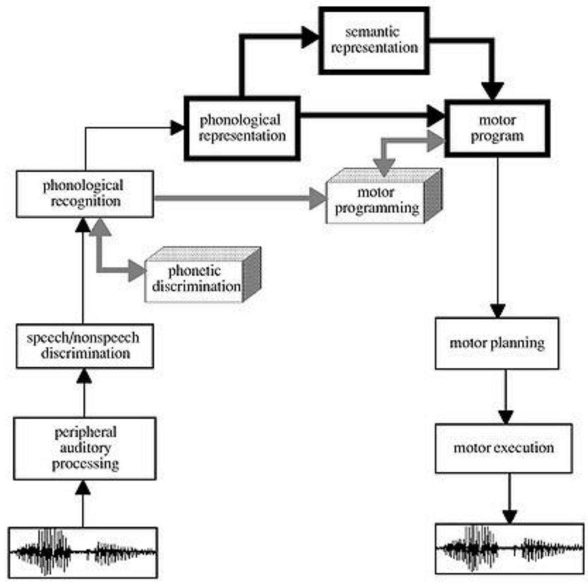

Figure 2.1 The Stackhouse and Wells speech processing model (From Stackhouse &Wells, 1997)

In the model, as shown in Figure2.1, three emboldened boxes represent the child's stored knowledge about a word's form (*phonological representation*), its meaning (*semantic representation*) and the specific articulatory gestures required for its pronunciation (*motor program*). Input processes include *peripheral auditory processing*, *speech versus nonspeech discrimination* and *phonological recognition*, where speech is recognised as child's native language and sent on for further decoding and comparison with stored phonological representations. Novel phonetic material can be recognised and learnt by an off-line level of processing called *phonetic discrimination*. The other offline process (also depicted with broad arrows and a shaded box) is *motor programming*, where new motor programs are created. Assembling motor programs into an utterance involves *motor planning*. The motor plan is executed and gives rise to an acoustic signal at the level of *motor execution*.

Stackhouse and Wells (1997) presented the case of Zoe and used their single word speech processing model to formulate hypotheses about input and output speech processing and phonological awareness skills. A series of tests targeting various aspects of Zoe's speech processing abilities were used to evaluate these hypotheses. The authors then formulated post-assessment hypotheses regarding the loci of Zoe's speech and literacy difficulties. For example, when Zoe was 9;8 years, they noted that the major persisting locus of deficit was in motor programming. Although the child presented with difficulties in phonological recognition, phonological representations and motor programs, these limitations were more restricted to particular words and to particular phonological oppositions.

Nathan, Stackhouse, and Goulandris (1998) showed that children experiencing difficulties with both speech and language had poorer speech processing abilities in relation to typically developing children than children with speech difficulties only.

The main clinical advantage of identifying the loci of speech difficulties is to inform any subsequent intervention. Decisions can be made, for example, on whether to focus on improving input discrimination, updating representations or improving motor execution skills. A psycholinguistic investigation with Robert, a 7-year-old boy with cerebral palsy, indicated different loci of breakdown across different speech sound errors (Rees, 2001). Rees (2001) therefore suggested that, for some words, therapy aims would need to focus on auditory discrimination whereas, for other words, aims would need to focus on updating motor programmes and/or motor execution skills.

Constable, Stackhouse, and Wells (1997) present the case of a seven year old boy with severe word finding difficulties. The potential levels of impairment for access to verbal representations were investigated. Originally language tests were administered, which revealed that there was not a difficulty in semantics adequate to account for the child's word finding difficulties. A series of consecutive assessments of phonological processing provided evidence that the difficulties were due to poorly defined phonological representations and insufficient links between lexical representations.

The Stackhouse and Wells speech processing model (Stackhouse & Wells 1997) has been applied to the assessment of various groups of children with speech difficulties including children with epilepsy (Vance, 1997), children with word-finding difficulties (Constable, Stackhouse, & Wells, 1997; Constable, 1997), children who stutter (Forth, Stackhouse, Nicholas, & Cook, 1996) and deaf children (Ebbels, 2000; Rees, 2009). According to Dodd (2014): p.193 ‘the major strength of the psycholinguistic framework is in demonstrating that children with SSD who share the same aetiology had different deficits in speech processing, revealing the complexity of associations between causal factors and associated deficits’.

The speech processing model of Stackhouse and Wells (1997) is a detailed and descriptive model that can be applied to investigate the development of speech processing skills at the age group of 3;0-6;0 years, that is the focus of the current project. In conjunction with the speech processing profile, it provides a comprehensive way of organizing assessment, devising task material, interpreting performance. It can also be used to inform the design of interventions and to describe with precision the demands of an intervention activity.

Other approaches as for example the minimal pair treatment (Gierut, 1989, 1990) where word pairs that differ by a single phoneme are used to develop awareness of contrastive differences could not be effectively adapted to Greek given the extremely limited number of minimal pairs in the language.

The Psycholinguistic approach can be adapted to the Greek language. It has already been successfully applied in order to assess and profile Greek children with speech difficulties (Geronikou & Rees, 2015). The psycholinguistic framework and speech processing model of Stackhouse & Wells (1997) form the theoretical basis of the current project in order to (a) investigate the development of speech processing abilities in typically developing Greek-speaking children, (b) assess and profile children with speech and language difficulties and (c) deliver intervention and interpret intervention outcome.

2.3 Assessment of speech processing

2.3.1 Assessment of speech input

Findings that show a relationship between input processing and language development (Tsao, Liu, & Kuhl, 2004; Edwards, 2002) and language impairment (Corriveau, Pasquini, & Goswami, 2007; Ziegler, Pech-Georgel, George, Alario, & Lorenzi, 2005; Reuterskiöld-Wagner et al., 2005) have been presented in Section 1.6.1.

The importance of assessing input skills of children with speech disorders has been demonstrated by a number of studies.

Conventionally speech errors of children with dyspraxia have been considered to arise from oral-motor control deficits. However, Bridgeman & Snowling (1988) found that children with dyspraxia performed significantly worse than controls in nonword discrimination when they had to identify differences in the series of phonemes. This difficulty was attributed to a deficit in processing and analysis of incoming novel speech stimuli in the absence of lexical representations.

Edwards et al. (2002) used auditory discrimination of CVC words with different properties of final consonant in order to investigate auditory discrimination abilities in a group of pre-school children with phonological disorder. The clinical group performed significantly below age matched controls both in whole word and gated conditions. These findings are thought to provide evidence for generalized difficulties with speech perception, at least for some children with phonological disorders.

Rvachew & Grawburg (2006) investigated auditory discrimination abilities in a group of 4 and 5 year old children with speech disorders. Half of the children in the group had significant difficulties with speech perception. Interestingly when a linear structural equation model was used speech perception abilities were found to have a direct effect on phonological awareness development. It was suggested that speech perception abilities should be assessed even in the presence of intact receptive language and vocabulary skills.

2.3.2 Assessment of phonological representations

Underlying representations i.e. the “part of the mental lexicon that stores the information needed to recognize and produce words” (Stoel-Gammon, 2011: p. 17) are important for the development of both spoken and written language.

The development and integrity of phonological representations has been assessed in typically developing children usually by asking them to decide if a word they hear is correct for a picture they see. Vowel mismatches and single-consonant substitutions are the most difficult to detect (McNeill & Hesketh, 2009). Older children are more able to accept correct and reject erroneous productions of words while reaction time decreases (Claessen, Heath, Fletcher, Hogben, & Leitão, 2009). Performance on the task correlates with performance on phonological awareness tasks and is predictive of reading and spelling ability (Claessen, Leitão, & Barrett,2010).

Vocabulary comprehension and production has been connected to integrity of underlying representations. Bryan and Howard (1992) present the case of a child with limited receptive vocabulary, deviant phonological production and appropriate nonword repetition performance. Restricted vocabulary comprehension is attributed to the fact that the child makes use of previously formed representations and does not generate new accurate ones, equivalent to his processing capabilities at the current stage of development. Crosbie, Dodd, and Howard (2002) sought to understand the cause of difficulties in vocabulary comprehension in three cases of children with SLI. Only in one case were the difficulties associated with limited semantic knowledge. In the other two cases the cause was located as underspecified phonological representations. Word finding difficulties in production have also been attributed to imprecise representations. Constable et al. (1997) present evidence for the connection between accurate phonological representation (as shown by the ability of a child to accept the appropriate and reject the erroneous productions of a word) and the ability of that child to name that word.

Rvachew & Grawburg (2006) report that in a group of four and five-year-old children with speech disorders who were receiving intervention, half of the participants had significant difficulty with tasks tapping phonological representations. In a study by Sutherland & Gillon (2007) typically developing children were found to outperform children with moderate or severe speech impairment on a word accuracy decision task. These findings suggest that some children with speech impairments have difficulty in storing and/or accessing accurate phonological representations. However, participants in these studies were not tested with other kinds of auditory discrimination tasks, so there is a possibility that they also had more general auditory discrimination difficulties.

2.3.3 Assessment of speech output

Assessment of speech production has been of great interest for clinicians and researchers for a number of reasons.

Firstly, it is important to recognize the developmental stages of speech production. Data on the typical and atypical development of phonetic inventory (Shriberg, Austin, Lewis, McSweeny, & Wilson, 1997b; Stoel-Gammon, 1985), phonological processes (Grunwell, 1981, 1992), diadochokinetic skills (Williams & Stackhouse, 1998) across childhood, assist the clinical evaluation and identification of children who require intervention.

Secondly, it is essential to be aware of the adequacy of the speech production system for a comprehensive assessment of a child's expressive language. The difficulties in speech and language domains might not only coexist, but also interact: speech production skills may adversely affect performance in language tests and assessments of nonword and sentence repetition, considered to be clinical markers of SLI. Some researchers (Dollaghan & Campbell, 1998; Seeff-Gabriel et al., 2010; Shriberg et al., 2009) aim to address this issue with appropriate test design and scoring guidelines. In addition there may be a reciprocal relationship between speech and language development. According to Dispaldro (2014) there are links between the prosodic features of language with grammar and nonword repetition. Both speed of articulation and linguistic processing have been found to contribute independently to speaking rate (Campbell & Dollaghan, 1995). Inconsistency in speech production relates to limited receptive vocabulary (Macrae, Tyler, & Lewis, 2014). Children with speech sound disorders (SSD) are less skilled in their general linguistic awareness than peers with typical sound production skills (Apel & Lawrence, 2011).

Thirdly, understanding levels and processes of speech production in typical and atypical development, improves assessment and intervention delivery for children with speech sound disorders. Study of output speech processing in typically developing children may inform our understanding about the processes taking place at the various stages of development. Vance et al. (2005) assessed typically developing children aged between three and seven years of age in three output tasks: naming, word repetition and nonword repetition. Results revealed, as predicted, that older children performed better than younger ones in all tasks. There was also an effect of age on performance across tasks with different profiles of performance for different age groups. Three-year-old children performed significantly better on both word and nonword repetition tasks than on naming. Four-year-old children performed significantly better on word repetition as compared to the other two tasks. From the age of five years children performed significantly worse on nonword repetition than on real word repetition and naming tasks. Vance et al (2005) suggested that young children make use of bottom up processes for repetition tasks whilst many existing motor programmes are still inaccurate, resulting in significantly worse performance in naming. Conversely from the age of five years the establishment of accurate lexical representations can be used in real word repetition and naming. The absence of top down support for nonword repetition could explain the significantly worse performance on this task. Hence using a wider range of output tasks can provide the clinician with useful knowledge on the mode of processing used (top down or bottom up) and an indication of whether the existing lexical representations assist or inhibit the child's ability to complete a task.

Williams & Chiat (1993) used four output tasks, i.e. naming, sentence repetition, word repetition and non-word repetition to assess in depth speech production in children with speech disorders. Children were divided into two groups of phonological delay and phonological disorder based on analysis of their errors in spontaneous speech. Comparison of performance across tasks revealed that children with phonological delay scored similarly in all four tasks. Children with speech disorder had different patterns of errors between tasks. Half of them had much better repetition than naming while the others made consistently the same number and type of errors in both repetition and naming tasks. Based on these differences on performance it was suggested that the first error pattern could be attributed to difficulties arising at the levels of motor programming and development of new motor plans, while the second error pattern could be attributed to inaccurate output representations.

Vance et al. (2005) provide evidence that in typically developing children speech production is less accurate for longer words. Production accuracy in output tasks decreases as word length increases. Children's speech production was less accurate for the longer words, suggesting that polysyllabic stimuli may be more sensitive in tracking speech production errors, that may not be apparent in short words. James, van Doorn, and McLeod (2008) highlight the importance of using polysyllabic items in assessment of speech production. James et al. (2008) provide evidence that impairment in speech, language, literacy and phonological processing may only be apparent in polysyllabic word production. It is suggested that assessment of polysyllabic word production provides unique information, necessary to inform clinical decision making.

2.4 The psycholinguistic profile

Based on the model, Stackhouse and Wells (1997) propose the use of a speech processing profile (figure 2.2). The profile consists of a series of questions about the child's speech processing abilities in terms of input processing, stored representations and output processing. It can be used as a tool to organize assessment data and demonstrate the particular strengths and weaknesses of a child. For the purposes of the current thesis the profile is used to present the results of the normative study in a comprehensive way. The psycholinguistic profile enables comparisons of performance on different tasks and at different time points between the two groups.

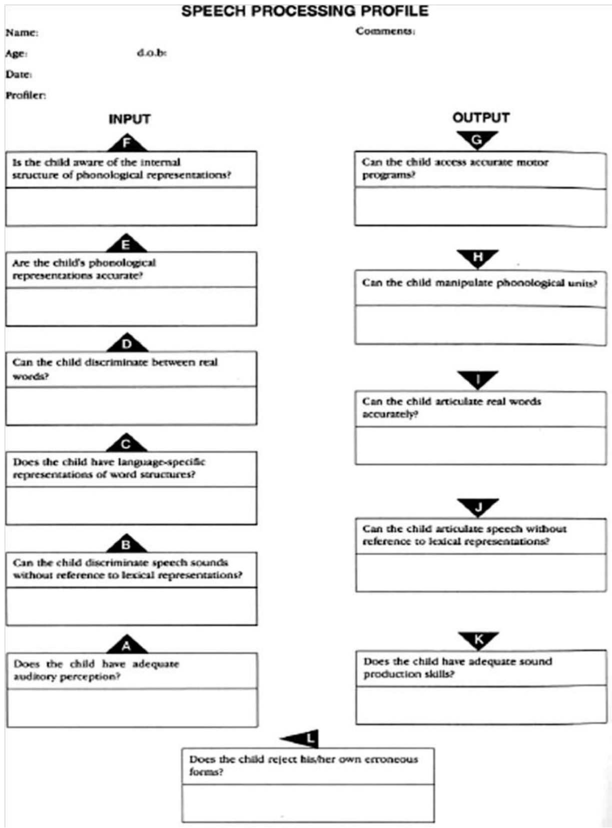

FIGURE 2-2: Stackhouse & Wells (1997) speech processing profile (From Stackhouse & Wells, 1997)

2.5 Speech difficulties

2.5.1 Classification of speech difficulties

Speech sound disorders affect between 10% and 15% of preschool age children (Broomfield & Dodd, 2001; McLeod & Harrison, 2009; McLeod, Harrison, McAllister, & McCormack, 2013; Okalidou & Kampanaros, 2001). Incidence of referrals indicates that the majority of children are assessed for the first time between 2 and 6 years of age (Broomfield & Dodd, 2004a). Nevertheless it is possible that by the time children start formal schooling their speech difficulties have not yet been identified (Broomfield & Dodd, 2004a; McKinnon, McLeod, & Reilly, 2007) nor resolved (McKinnon et al., 2007) thus setting constraints on the subsequent development of children's learning and social skills (McCormack, McLeod, McAllister, & Harrison, 2009).

For the majority of children there is not an identifiable causal factor of speech impairment (Broomfield & Dodd, 2004a). There is widespread agreement on the heterogeneity characterizing the group of children with speech disorders (Baker, 2006; Dodd, Holm, Crosbie, & McCormack, 2005; Shriberg et al., 1997b; Stackhouse & Wells, 1997). Differences between children with speech disorders are associated with the underlying cause, the pattern of errors, the extent to which these errors depend on other aspects of the linguistic and cognitive system, the response to treatment and the maintenance of these skills (Dodd, 2011). It is important to differentiate and classify speech sound disorders properly, in order to deliver targeted intervention and maximize the effect of treatment (Waring & Knight, 2013). However it is hotly debated whether speech disorders should be classified according to aetiology or symptomatology (Fox, Dodd, & Howard, 2002). Three prominent classification systems that have been proposed are: a) the Speech Disorders Classification System (Shriberg et al., 2010), b) Differential Diagnosis (Dodd et al., 2005), c) the Psycholinguistic Framework (Stackhouse and Wells, 1997).

1. The Speech Disorders Classification System (SDCS) (Shriberg et al., 2010). The system is not based on a theoretical model of speech development, but rather starts from a medical viewpoint that there is an association between genetic defect and speech difficulty. In the current version of the classification three main types of pathology are recognized: speech delay, motor speech disorders and speech errors. For each of the main types aetiological subgroups are proposed as for example otitis media with effusion for speech delay; dysarthria as a motor speech disorder. SDCS has been criticised by Fox et al. (2002) because specific risk factors such as perinatal problems are not included in the system's causal factors. In addition in certain cases there were more than one aetiological factor in parental reports, thus children could not be classified according to SDCS. This classification system has been used in research (Shriberg, 1993; Shriberg et al., 1997b; 2010) but is not yet designed for everyday clinical practice (Waring & Knight, 2013).

2. Differential Diagnosis (Dodd et al., 2005) is a classification model originating from descriptive linguistics. Starting from different patterns in surface speech errors, it is intended to identify subcategories of speech disorders associated with different underlying processing difficulties. Based on analysis of error patterns five subgroups of speech difficulty are suggested: Articulation disorder, phonological delay, consistent atypical phonological disorder, inconsistent phonological disorder and childhood apraxia of speech. Further investigation of linguistic, cognitive, output processing and motor execution skills led Dodd and her colleagues to suggest underlying processing profiles associated to subgroups. Consistent atypical phonological disorder is attributed to deficit at a cognitive – linguistic

level, affecting rule abstraction and cognitive flexibility. Inconsistent phonological disorder is attributed to a deficit in phonological assembly (Crosbie, Holm, & Dodd, 2009; Dodd, 2011; Dodd & McIntosh, 2008). Differential diagnosis has been effective in classification of Cantonese (So & Dodd, 1995), Mandarin (Hua & Dodd, 2000) and German speaking children (Fox & Dodd, 2001). The Diagnostic Evaluation of Articulation and Phonology (DEAP) developed by Dodd, Zhu, Crosbie, Holm, & Ozanne, (2002) is a standardized test based on the theoretical basis of Differential Diagnosis, readily applicable in clinical practice. However the Differential Diagnosis system has received criticism from Waring and Knight (2013) for several reasons: firstly, because different groups of children participated in different studies, therefore results may not be directly comparable; secondly, participants in different subgroups were not matched on vocabulary age and finally because, the validity of the multisyllabic word task, (a task requiring repetition of multisyllabic words) that is crucial for allocation of participants to different subgroups, has not been established and there are no validity data available for the task of legality judgment (a task requiring children to decide whether auditory stimuli are legal for their language i.e. follow the phonotactic rules of the language).

3. The Psycholinguistic Framework (Stackhouse & Wells, 1997). This approach, which has already been presented in detail in section 2.2.2, is a link between the medical aetiological classification and linguistic description. The framework was not developed with the intention of labelling children. On the contrary it highlights the uniqueness of each child and seeks to identify the potential disruption in the speech processing system that underlies the development of speech. The framework has been successful in profiling Greek speaking children with speech difficulties (Geronikou & Rees, 2015). The framework has been criticised on the basis that apart from input and output processing, cognitive deficits, such as executive function impact on speech processing. In addition the predictive validity of the framework is doubted on the grounds that every child presents with a different profile of strengths and weaknesses (Waring & Knight, 2013).

2.5.2 Description of speech characteristics

According to Dodd (2014) 'the way a child's speech is described reflects researchers' and clinicians' understanding of the behaviour' (p.190). Research seeks to identify means of measuring speech disorders that are representative of a child's difficulty and able to identify changes that arise as a result of treatment.

Analysis of phonological patterns that govern a child's speech in relation to adult targets is used as part of standardized speech assessments (Dodd et al., 2002) and is widely used in clinical practice (Rvachew & Brosseau-Lapré, 2012). Phonological Analysis of Child Speech (PACS) (Grunwell, 1985) includes a detailed description of the phonetic inventory, including how it is realized in different phonotactic structures and different positions within the word. It is considered that PACS system is a developmentally adequate way of illustrating phonetic and phonological output in order to plan intervention (Müller, Ball, & Rutter, 2006). Nevertheless, it cannot be used as a measurement of change as a result of intervention, as it has not been converted to a quantifiable measure (Newbold, Stackhouse, & Wells, 2013).

Percentage Consonants Correct (PCC) counts the number of accurately produced consonants in order to estimate the severity of speech difficulty (Shriberg, Austin, Lewis, McSweeny, & Wilson, 1997a). PCC is often reported in speech disorders research (Lousada et al., 2013; McLeod et al., 2013; Pascoe, Stackhouse, & Wells, 2005). There is no provision taken for developmentally appropriate errors, omission, substitution and distortion of speech sounds (Dodd, 2014). However, PCC is sensitive enough to track change as a consequence of intervention, even in cases where different stimuli are used at different assessment points (Newbold et al., 2013)

2.5.3 Intervention approaches

The present study takes the form of a normative study that investigates the development of language and speech processing abilities in Greek children aged 3;0-6;0 years and two intervention case studies of children with speech difficulties investigating the extent to which speech therapy to develop phonological or morphological skills impacts on the development of speech, language or both. Therefore, it is important to review current intervention practice. Different theoretical approaches to diagnosis have different implications for intervention. Decisions about intervention targets and procedures might be guided from the theoretical conceptualization for speech difficulties. For example, a clinician adopting the Differential Diagnosis classification system (Dodd et al., 2005) may wish to apply specific intervention strategies that are considered to be effective on specific subtypes of speech difficulty. Whereas, a clinician adopting the psycholinguistic perspective (Stackhouse & Wells, 1997) may wish to devise intervention tasks expected to tap a child's weaknesses in speech processing.

There is a plurality of different strategies for the selection of targets and the provision of intervention in children with speech disorders.

In the nineties (Gierut, 1998) referred to sensory-motor and cognitive-linguistic approaches used to improve the production of sounds and increase intelligibility. In the literature of the era extensive use and proven efficacy were reported for four approaches. These were: traditional approach (Van Riper & Emerick, 1984), cycles approach (Hodson & Paden, 1991), minimal pair treatment (Gierut, 1989, 1990) and Metaphon (Dean, Howell, Waters, & Reid, 1995). There were indications (Tyler, Edwards, & Saxman, 1987) that the minimal pair approach is more appropriate for children with focused error patterns whereas children with broader phonological problems may benefit most from the cycles approach. Different intervention strategies were used in each approach (Fey, 1986), therefore a direct comparison of the effectiveness of diverse approaches was not feasible. However, the positive effect of those approaches was well established (Gierut, 1998).

In a more recent narrative review of intervention studies for children with speech sound disorders Baker and McLeod (2011) identified seven approaches to target selection: developmental approach (Rvachew & Nowak, 2001), cycles approach (Williams, Hodson, Nonomura, & Zappia, 1989), non-linear approach (Bernhardt & Major, 2005), whole language approach (Hoffman, Norris, & Monjure, 1990), psycholinguistic approach (Pascoe et al., 2005) and complexity approach (Gierut & Champion, 2001). In the same review the authors identified 46 distinct approaches to intervention. This multitude of approaches reflects the range of research undertaken internationally in the field of intervention. Moreover, it is attuned with the fact that in everyday clinical practice therapists combine intervention techniques, with positive results for children with phonological difficulties (Lancaster, Keusch, Levin, Pring, & Martin, 2010).

A special issue of the journal *Advances in Speech- Language Pathology* was devoted to the application of different perspectives to the management of a single child. Linguistic profiling

(Müller et al., 2006), nonlinear phonology (Bernhardt, Stemberger, & Major, 2006), learnability theory (Morrisette, Farris, & Gierut, 2006), core vocabulary approach (Dodd, Holm, Crosbie, & McIntosh, 2006), psycholinguistic approach (Stackhouse, Pascoe, & Gardner, 2006), systemic perspective (Williams, 2006), cycles approach (Hodson, 2006), motorically based intervention PROMPT (Prompts for Restructuring Oral Muscular Phonetic Targets) (Hayden, 2006) and PACT (Parents and Children Together in phonological therapy) (Bowen & Cupples, 2006) were used to provide intervention goals for a seven year old boy with unintelligible speech. Analysis and interpretation of assessment data, diagnosis and treatment planning for this child with speech disorders varied depending on the theoretical background of the researchers and therapists involved, indicating that focus on different aspects of linguistic and non-linguistic development impacts on intervention planning. Although different approaches to therapy were suggested, there was sufficient theoretical justification for intervention planning and target selection for each of these approaches. It was shown that different perspectives can be applied and 'all intervention approaches have their merits' Dodd et al. (2006, p.229).

Literature reviews (Baker & McLeod, 2011; Gierut, 1998) and meta-analysis (Law, Garrett, & Nye, 2004) of research papers suggest that at the present time there is only a limited number of studies documenting that one therapeutic approach is more effective than others for a particular population. Intervention studies are vital to guide therapists in the use of evidence based practice in clinical settings.

2.5.4 Effects of intervention on phonology and morphology

Randomized control trials have been used in the study of groups of children with speech disorders, randomly allocated in experimental conditions, to investigate the effectiveness or the efficacy of a particular intervention approach in comparison with another. This type of research design has been used in intervention studies such as: comparison of minimal pairs with non-minimal pairs (Dodd et al., 2008), the effect of grammar intervention on phonological performance (Fey et al., 1994), the development of phoneme awareness following phonological awareness intervention in comparison to language stimulation intervention (Hesketh, Dima, & Nelson, 2007), the effect of choosing targets that require bigger or smaller amounts of productive phonological knowledge on phonological development post intervention (Rvachew & Nowak, 2001), the development of speech production skills as a result of a perceptual approach in addition to regular speech language therapy (Rvachew, Nowak, & Cloutier, 2004).

There are a number of group studies of children with co-occurring speech and language difficulties that seek to investigate the direct effects of intervention that targets either speech or language, as well as indirect effects, i.e. the effects on areas other than the one targeted. These studies are of particular importance for the aims of the current thesis, where intervention case studies are used to investigate the production of morphology in children with speech disorders.

Tyler, Lewis, Haskill, and Tolbert (2002) used the cycles approach with focused stimulation techniques and an elicited production component in blocks of intervention targeting either phonology or morphosyntax for a group of 20 preschool age children with impairments both on phonology and morphosyntax. Participants received intervention for a 12 week period. They were randomly assigned to intervention starting with a block of phonology followed by a block of morphology, or intervention starting with a block of morphology followed by a block of phonology. Research questions concerned treatment efficacy of phonological intervention on phonology, morphological intervention on morphology, cross domain effects of morphological intervention on phonology and vice versa, and sequence effects related to which of the two domains should be targeted first to achieve greatest gains. Results indicated that both treatment groups made statistically significant progress in the treated domain as compared to a control group of seven children who did not receive any intervention. A cross-domain effect was demonstrated, with changes in phonology for the group of children who received morphosyntax intervention first. According to Tyler et al. (2002) the children whose errors are the most inconsistent, are the ones who show the greatest gains in phonology from a morphosyntactic intervention. It is possible that such an approach permits greater exposure to and/or production of different phonemes across positions, than in traditional phonological approach. Tyler et al. (2002) raise the possibility that morphosyntax intervention facilitates phonological development because sounds are learned and practiced as part of larger linguistic units. Overall morphosyntactic performance was slightly better when morphosyntax was targeted prior to phonology, suggesting that children's speech does not have to be fully intelligible for language intervention to commence.

Tyler, Lewis, Haskill, and Tolbert (2003) further compared the outcomes of four different goal attack strategies: (a) 12 weeks of intervention targeting phonology followed by 12 weeks of intervention targeting morphology, (b) 12 weeks of intervention targeting morphology followed by 12 weeks of intervention targeting phonology, (c) 24 weeks of intervention alternating phonological – morphological targets weekly, (d) 24 weeks of intervention simultaneously targeting phonology and morphology. Results indicated that no single goal attack strategy was superior in improving phonology post 24 weeks of intervention. The alternating strategy was the one associated with greatest gains in morphosyntax post intervention. Phonological intervention resulted in significant change in phonology but not in morphology. A plausible explanation could be that phonological intervention in this study targets the production of word initial sounds rather than word final sounds, which would signal change in morphosyntactic properties. In addition it is possible that few children in the phonological intervention group had morphological difficulties that could be attributed to phonological limitations. Treating phonology may be beneficial for morphological difficulties, when these are related to phonological factors.

Tyler et al. (2003) draw attention to large standard deviations in variables measuring morphosyntactic and phonological change, indicative of high variability in response to intervention for individual participants in the same group. They raise the possibility that one type of intervention may not have been equally beneficial for all participants in a group. Individual children may respond differently from others in the group. It is possible that differences in starting level and type of errors among participants led to individual variation in intervention outcome and generalization. Individual analysis would be informative about treatment efficacy for particular profiles of difficulty. Such an analysis is more feasible within the context of a single case study.

Single case studies have the potential to elucidate individual differences and allow for an in depth evaluation of treatment efficacy on particular children (Pascoe et al., 2006).

A pioneer single case study in the area of morphological and phonological change in a child with speech and language difficulties following intervention was conducted by Seeff-Gabriel, Chiat, and Pring (2012). The individual profile of difficulties, intervention planning and delivery in the case of B, a five year old boy with speech and language difficulties was presented in detail. B had difficulty with the production of regular past tense, although he was able to produce /t/, /d/ in word final position, suggesting that his difficulty could be morphosyntactic. He also had difficulty with the production of plural nouns, and he was unable to produce /s/, /z/ in final position, suggesting a speech difficulty with phonology required for marking plurals.

Intervention initially targeted the production of regular past tense using demonstration, bombardment, judgment and elicited production activities. After 10 weeks of intervention B's production of past tense improved significantly both for treated and untreated regular verbs and this ability was maintained after 8 weeks of no intervention. However, this did not generalize to irregular verbs. It is also worth noting that after therapy most errors were observed in verbs ending in /t/, thus requiring the past tense ending /ɪd/. This, according to Seeff-Gabriel et al. (2012) suggests that despite the fact that his difficulties were morphosyntactic, past tense marking was influenced by phonological factors.

Intervention then targeted the production of /s/ as a phonological precondition for the accurate production of nouns in plural. Traditional articulation intervention techniques were used to facilitate the production of /s/ in isolation and then in word final position (in nouns such as *dress, dice* that the child was able to understand as indicated on a picture – pointing task). It was hypothesized that if phonological factors were preventing the accurate production of nouns in plural, plurals should be marked post intervention, without being directly targeted. After 5 weeks of intervention B was able to produce word final /s/ accurately, but his production of word initial and word medial targets did not improve. Therapy targeting final /s/ induced plural marking. B was able to mark 33/34 plurals with a word final consonant, but phonologically accurate production was limited to 8/34 targets, suggesting that he did have the morphological knowledge but not the necessary phonology to realize plurals in speech. In most cases, irrespective of whether the plural required /s/or /z/, B stopped the final consonant to /d/. Moreover, correct production of /s/ had not generalized to /z/ and his production of word-initial and medial /s/, /z/ targets did not improve in a confrontation naming task.

A third phase of intervention targeted directly /z/ in word final position. Intervention included minimal pair discrimination between /z/ and /d/ plus traditional articulation intervention techniques to facilitate the production of /z/ in isolation and then in word final position. After 5 weeks of intervention B was able to produce /z/ accurately in monomorphemic targets in word initial and word final position, while production in word within position improved considerably. However, stopping of final /z/ required for plural marking remained. This difficulty with plural marking was attributed to aggregated difficulties of speech and morphosyntax, indicative of an interaction between the two domains (Seeff-Gabriel et al., 2012).

This study shows how single case studies can reveal in detail the reciprocal relationships between speech and language in individual children. This study is of particular importance for the scope of the present thesis, as it describes how the domains of phonology and morphology may be targeted in intervention, and possible interactions in the outcome of intervention. In chapter six intervention case studies are presented for Greek speaking children with speech difficulties, targeting the production of /s/ a phoneme used in multiple morphological contexts. The effect of intervention is evaluated for phonological targets, morphological targets and across domain generalization.

2.6 Summary

The establishment of clinical markers and the use of diagnostic tools are critical in identifying children with language disorders, both for research purposes and for clinical practice.

Significant markers that distinguish between typical and deviant language development are considered to be: grammatical tasks, nonword repetition, and sentence repetition.

The grammatical tests proposed as diagnostic markers are: 1) The past tense of verbs in English (Rice & Wexler, 1996) and Greek (Mastropavlou, 2010), although there is disagreement about whether the difficulty is only evident in irregular verbs (Blake et al., 2004) or in regular verbs as well (Marchman et al., 1999; Rice & Wexler, 1996). 2) the third person singular for English (Conti-Ramsden et al., 2001; Rice & Wexler, 1996) and the third person plural for Italian (Bortolini et al., 2006; Dispaldro et al., 2013a) and Spanish (Bedore & Leonard, 2001, 2005). 3) The subject verb agreement in German (Clahsen et al., 1997) and Greek (Clahsen & Dalalakis, 1999). 4) The production of object clitics for children with SLI whose native language is Spanish (Bedore & Leonard, 2001, 2005), Italian (Bortolini et al., 2006; Dispaldro et al., 2013a), Greek (Smith et al., 2008) and French (Jakubowicz et al., 1998; Paradis & Crago, 2001). The difficulty in the proper use of grammatical morphemes is attributed either to prolonged use of infinitive types (Rice & Wexler, 1996), or to limited capacity of memory (Blake et al., 2004), or to whether morphemes are readily perceived depending on the length of the word and the intonation of the word in the sentence

(Leonard, Eyer, Bedore, & Grela, 1997) or to the grammatical category and the properties of the target (Jakubowicz et al., 1998).

With regard to nonword repetition there is a general consensus among researchers that it is a significant clinical marker associated with language development. Nevertheless there is disagreement over the possible cause which governs this link. It has been suggested that nonword repetition is independent of language ability (Baddeley et al., 1998; Gathercole & Baddeley, 1989) and that it is a clear measure of phonological short-term memory. The fact that the length of stimuli impacts on performance in the test, has been interpreted as evidence of a relationship between repetition ability and memory capacity. However it is argued that other factors, such as production abilities are linked with nonword repetition (Shriberg et al., 2009; Snowling, Chiat, & Hulme, 1991). In addition, research data indicate that there is impact of different linguistic factors in nonword repetition performance such as: the presence of high frequency phonemes; clusters (Coady, Evans, & Kluender, 2010); whether the stressed syllable of the NW corresponds to real word (Dollaghan, Biber, & Campbell, 1993; Dollaghan, Biber, & Campbell, 1995); whether the nonword includes existing morphological elements (Casalini et al., 2007), and whether the nonword closely resembles real words (Gathercole, Willis, Emslie, & Baddeley, 1991). Therefore the argument that nonword repetition is independent of the language system is highly questionable. In line with the various theoretical explanations on the mechanisms involved in nonword repetition, different assessment tools have been developed so that the stimuli which constitute the test include verbal characteristics such as morphemes (Gathercole & Baddeley, 1996), or do not include word components (Dollaghan & Campbell, 1998) or take provision for the phonological features like the phonotactic structure and the age of acquisition of the constituent phonemes (Shriberg et al., 2009).

More recently sentence repetition was proposed as a diagnostic marker (Conti-Ramsden et al., 2001; Seeff-Gabriel et al., 2010). Based on the observation that increasing the length of sentences reduces repetition accuracy, without a corresponding decrease in comprehension (Willis & Gathercole, 2001) suggested that sentence repetition depends on phonological short-term memory. In contrast to this position is the view that linguistic characteristics, both morphological and syntactic, impact on sentence repetition (Seeff-Gabriel et al., 2010) and that sentence repetition is related to the MLU and reflects competence for sentence production in spontaneous speech (Devescovi & Caselli, 2007; Stokes et al., 2006).

Recently, researchers (Riches, 2012) agree on the multidimensional nature of the test, which places demands on grammatical and syntactic knowledge, phonological and working memory.

In the endeavour to understand the nature of language development and language difficulties, one cannot ignore the speech processing system. A common ground between theoretical approaches of speech is the presence of input, storage and production processes.

The psycholinguistic model of Stackhouse & Wells (1997) allows in-depth study of difficulties, in order to identify areas where difficulties arise and devise appropriate intervention.

The model has been applied in the evaluation of children with a range of language (Constable et al., 1997) and speech disorders revealing that even in cases of children with similar aetiology, different weaknesses in speech processing may be involved (Dodd, 2014).

Research findings indicate that children's language development is linked to input processing skills (Tsao, Liu, & Kuhl, 2004), whilst children with SLI have difficulties in input processing (Corriveau, Pasquini, & Goswami, 2007; Ziegler, Pech-Georgel, George, Alario, & Lorenzi, 2005). Speech difficulties may be related to input processing difficulties (Edwards, 2002) even in the case of childhood apraxia of speech (Bridgeman & Snowling, 1988).

Another potential field of difficulty lies in the representations. Representations are developed gradually (Claessen, Heath, Fletcher, Hogben, & Leitao, 2009; McNeill & Hesketh, 2010) and their accuracy is related both to the vocabulary development (Bryan & Howard, 1992; Crosbie et al., 2002), and subsequent reading and spelling ability (Claessen & Leitão, 2012; Claessen, Leitão, & Barrett, 2010). Underspecified representations, insufficiently defined have been identified in children with speech disorders (Rvachew & Grawburg, 2006; Sutherland & Gillon, 2007).

The evaluation of production allows comparison of the articulation of a child to what is developmentally anticipated, in terms of phonological characteristics (Grunwell, 1981) and oral motor skills, including diadochokinetic skills (Williams & Stackhouse, 1998). Evaluation of speech also allows investigation as to whether speech difficulties have an impact on expressive language test performance (Seeff-Gabriel et al., 2010).

For the classification of speech disorders, different systems have been proposed. The Speech Disorders Classification system (Shriberg et al., 1997b) focuses in the connection of speech disorders to specific medical etiological factors. Differential Diagnosis (Dodd et al., 2005) seeks subcategories of speech disorders based on surface errors in speech production. The Psycholinguistic approach (Stackhouse & Wells, 1997) treats each child as a unique entity and examines the underlying mechanisms of the speech processing system, from which speech disorders arise.

According to the psycholinguistic approach comparison of performance in different tests can provide information both for the developmental changes that occur over time (Vance, Stackhouse, & Wells, 2005) and for the possible cause of difficulties(Williams & Chiat, 1993; Stackhouse & Wells, 1997).

The Psycholinguistic profile, a series of questions about the speech processing abilities, is a method of encoding and interpreting data. The profile is used in Chapter 4 of this thesis for the presentation of the results of the normative study, the description of the skills developed by children at each age and the identification of developmental changes.

A variety of intervention approaches and strategies have been proposed to address speech and language disorders. Among these, studies of Tyler et al. (2002, 2003) suggest that intervention targeting morphological skills, can have positive effects on the development of phonology and that intervention targeting in parallel phonological and morphological objectives may be beneficial in children. A case study, presented by (Seeff-Gabriel et al., 2012) indicates that sometimes the level of phonological skills development is insufficient for the proper realization of morphophonemes in speech, therefore intervention targeting difficulties in phonological and morphological level is necessary. Intervention case studies presented in Chapter 6 seek to investigate the effect of phonological and morphological focus of intervention on speech and language development.

2.7 Aims of the study

The study will explore the relationship between short term memory, input processing skills, and phonological awareness in the language acquisition of Greek speaking children. Issues of interest will include the acquisition of morphology and phonology, vocabulary development, and integrity of representations especially for polysyllabic words. Specific aims are:

- To investigate the development of speech processing abilities in typically developing Greek speaking children aged 3; 0 – 6; 0.
- To investigate the development of morphology in relation to the development of speech processing skills, as a part of the speech processing system.
- Having assessed and profiled children with speech and language difficulties in order to identify potential candidates for morphological and phonological intervention, to deliver psycholinguistically driven intervention and to interpret intervention outcomes with respect to changes in the production of morphology.

Chapter 3. Methodology

3.1 Design

The first part of the current thesis is a cross sectional longitudinal study investigating the development of speech processing skills and in particular the development of phonological and morphological skills, in preschool age Greek speaking children. Children are assessed three times with a six months intermission between each assessment. Results of the normative study are presented in chapters 4 and 5. The second part of the thesis involves intervention in the area of phonological and morphological production. Two intervention single case studies seek to investigate the relationship between morphological and phonological development. Case studies and details of those two participants are presented in chapter 6.

3.2 Participants of the normative study

Children are divided in two age groups: Group 1 (younger ones) aged 3; 0 -3; 6 years and Group 2 (older ones) aged 4; 6 – 5; 0 years at the beginning of the study. Thirty-eight children in total participated in the study at T1. The characteristics of the participating children can be seen in Table 3-1.

Table 3-1 Participants of the normative study

		Group 1 3;0 -3;6	Group 2 4;6 -5;0
Participating children	Boys	7	14
	Girls	9	8

All children had Greek as their primary language. Bilingual children were included under the condition that one of the parents was a native Greek speaker and that the child had been attending a Greek speaking setting at least for six months. Parental consent and child assent was gained prior to testing. There were a small number of children in Group 1 and a child in Group 2 who were not willing to participate despite their parents' consent, thus were not included in the study. All the participants lived in the urban area of Patras in western Greece. The younger participants (Group 1) were recruited at a state day-care setting accepting children from the district of Patras and the older ones (Group 2) were recruited from five state kindergarten schools accepting children from their area. Heads of all local day-care nurseries and kindergarten schools[3] were approached, provided with information sheets to be given to parents and asked if they would agree for their setting to be involved in the project. For those who agreed, teaching staff were asked to nominate children who fit the selection criteria. The teachers approached the parents of these children, explained that a research project was to be conducted in school and provided parents who were interested in participating with an information sheet and consent form. Where both the consent of the parent and the assent of the child were obtained, children were recruited to the study.

All children passed a hearing screening test at 20 dB for frequencies 250 – 2000 Hz. In order to ensure that children have normal hearing and would be able to complete the input tasks a screening hearing test was conducted using the Home audiometer software. Frequencies at 250, 500, 1000 and 2000Hz were tested with a 1sec signal with a gap of 3 sec between each signal and the initial sound was given at 20 dB HL.

Participants either had no vision problems or vision problems that were corrected with glasses. It was important to ensure that visual problems would not affect performance on the tasks.

In order to ensure that there were no structural or functional abnormalities of articulators and that children were able to produce movements that result in recognisable vowels, consonants and clusters of the language a diadochokinetic task was used. In all phases of assessment children were asked to repeat single syllables and sequences of syllables. Stimuli were presented orally by the researcher and the children were asked to repeat as well as possible what was heard. Some sound and syllable repetitions that are widely used in clinical assessment e.g. /pa/, /ta/, /ka/, /pataka/ as well as some experimental sounds /sa/, /za/, /ksa/, /psa/ that in Greek mark the use of a different morpheme were used. In order to be involved in other output tasks, children should be able to produce the syllables and repetitive syllables. However, articulatory errors for sounds that are not expected to be in the phonetic

[3] For the administration of the assessment battery in kindergarten schools ethics approval was gained from the Institute of Educational Policy, Greek Ministry of Education.

inventory of children at a young age (for example /s/ for three year old children) were accepted as successful performance, provided there was a consonant in syllable initial position. Difficulties with sequencing of different syllables and slow rate were also acceptable, provided that children produced at least two successive Consonant-vowel (CV) structures.

The state day care settings in Greece accept children at the age of 2 years 6 months up to the age of five years. Children are allocated to classes according to their age. They do not follow a standard curriculum. The staff in charge develop daily activities such as structured play, signing, drawing, and craft, reading of fairytales, free play, group activities and individual activities.

The kindergarten schools accept children at the age of four, at a pre-kindergarten level of education, however formal education at that age is optional; children can be still attending a day care setting or even stay at home. At the age of five going to kindergarten is part of compulsory education in Greece. Children are allocated to mixed classes of pre-kindergarten and kindergarten children, as the number of pre-kindergarten children in a school is usually small. In kindergarten schools teachers follow the national curriculum and develop daily activities in the following areas: language, maths, computers, arts, humanities and natural environment. Language activities may include logographic reading and phonological awareness tasks such as the identification of the first sound of a word or the production of a series of words beginning with the same sound. The students attend the school till noon and certain kindergarten schools, the so called whole-day schools, offer the option of staying at school after the completion of the curriculum activities, till early afternoon. In order to maximise the possibility that at each of the latter two points of assessment the children of group 2 would be still attending the same setting in which they were initially assessed it was decided to recruit to this group only children who were attending the school as pre-kindergarten students. The children were attending the school till afternoon and the assessment sessions were conducted after the completion of the curriculum activities.

In order to conduct the normative study of speech and language development a number of published material as well as some experimental tests are used.

3.3 Brief introduction to the tasks and materials used in the study

The focal point of the current thesis is to investigate the development of morphology and in particular to investigate the development of morphology in relation to the development of speech processing skills, as part of the speech processing system. It is hypothesized that the acquisition of morphology, depends on the adequacy of the child's speech processing skills. Phonologically related speech processing tasks are used to investigate the development of speech processing skills. In order to assess speech processing skills a number of experimental tasks have been devised following the principals of the Stackhouse & Wells (1997) psycholinguistic framework. A block of phonologically related stimuli is used to assess each speech processing skill, for example auditory discrimination of real words.

As in the case of phonological stimuli, for each processing level a block of stimuli of morphological interest has been devised to assess input and output processing for morphological elements of the language. Morphologically related stimuli reflect pairs of minimal morphological difference for example a difference in pronoun gender when case and number are the same, a difference in verb tense when person, number, voice are the same.

These morphologically related speech processing tasks are used to investigate whether input and output skills are developing for the processing of morphological elements of the language, as part of the speech processing system.

In addition , a set of language tasks are used to evaluate the development of language skills, including the comprehension and production of morphology. Language production skills are assessed at single word and sentence level, in elicited and spontaneous conditions.These language tasks are used a) to establish that participating children are typically developing and

b) to provide a comprehensive evaluation of their language skills, in order to gather detailed information concerning the development of morphology both for comprehension and production in typically developing children, as well as other language skills being developed in parallel,including syntax and vocabulary. This is because both speech and language skills need to be measured to investigate relationships between speech and language and to find out whether the development of morphology is related to the development of speech processing skills.

In summary, in the present study a range of a) phonologically related speech processing tasks, b) morphologically related speech processing tasks and c) language tasks are used to investigate the development of morphology in relation to the development of speech processing skills and language skills.

3.4 Published tests

3.4.1 Diagnostic Verbal IQ test (DVIQ, Tsimpli & Stavrakaki, 2001)

The DVIQ is designed specifically for Greek speakers and aims to assess the receptive and expressive skills of preschool children aged 2; 6 to 6; 5 years. It is in the process of standardization and preliminary norms from 291 preschool children are available, corresponding to three age groups (i) 3; 5- 4; 11 years, ii) 5; 0 -5; 11 years, iii) 6; 0-6; 5 years. The test has been used in the past for matching purposes in studies of Greek SLI (Stavrakaki 2001; Mastropavlou 2006; Smith 2008). The DVIQ consists of five subtests: three of them aim to assess morphosyntactic skills and were selected to evaluate morphological skills, as morphological development is at the centre of the present study. Given that the number of tests that are available in Greek is very limited, DVIQ is used as a valid tool for the assessment of morphological development. The three DVIQ subtests that are used as a language measurement in the present study are described next.

3.4.1.1 The production of morphology and syntax

Description of the task: it is a picture based assessment with open ended phrases that trigger the production of several morphological phenomena e.g. plural formation, past tense, passive voice. The child sees two pictures, listens to an introductory phrase that describes the first one and then has to complete the rest of the phrase in order to describe properly the second picture.

Materials: Pictures were presented using power point presentation in a laptop computer. The researcher would point to each picture while speaking. The complete list of stimuli can be found in Appendix 1.

Scoring: the child is given one point for each correct answer; it is noted if there is an incorrect or no answer to a question. The maximum score is 24.

The task resembles the Word structure subtest of the Clinical Evaluation of Language Functions (CELF) (Semel, Wiig, & Secord, 1996) in that specific grammatical constructions are elicited from the child using picture prompts.

3.4.1.2 Comprehension of morphology and syntax:

Description of the task: the child listens to a sentence and has to choose the corresponding picture from three pictures.

Materials: Pictures were presented using power point presentation on a laptop computer. The researcher would point to all the pictures before speaking and then the child would point to the one that he/she thought best described what was said. The complete list of stimuli can be found in Appendix 2.

Scoring: the child is given one point for each correct answer; it is noted if there is an incorrect or no answer to a question. The maximum score is 31.

The task resembles the Sentence structure subtest of the CELF (Semel, Wiig, & Secord, 1996), where the child is given verbal instructions such as 'the girl is not climbing' and has to point to the corresponding picture from a choice of four. However in the Greek test the choice is between three pictures.

3.4.1.3 Sentence repetition:

Description of the task: the child has to repeat 16 sentences of increasing length and morphosyntactic complexity

Materials: According to the published version the researcher is expected to say each sentence for the child to repeat. However in this study the phrases were pre-recorded and presented through headphones to ensure that all the participants heard the stimuli under exactly the same conditions, with regard to rate, loudness and prosody. In order to keep children interested and motivated, scratch platform was used. Scratch is a visual programming language, developed by MIT Media Lab, Lifelong Kindergarten Group. The platform allows the use of visual stimuli such as cartoons, animation and background and audible stimuli such as sounds of musical instruments or recorded speech. The platform allows the creation of a story to be used in interactive mode. For example, a cartoon moves conditionally and can be under the control of a child or an adult. For the purpose of the current project a cartoon (for example a monkey) appeared in a tempting background (for example in the jungle, under a banana tree) and a story was presented to motivate the child in repeating the auditory stimuli (for example the child was asked to say out loud what was heard from the headphones in order to help the monkey climb up the tree and reach the banana). Under the control of the researcher stimuli were presented one at a time and the cartoon would not move till the child repeated the sentence. The complete list of stimuli can be found in Appendix 3.

Scoring: the child is given three points if the sentence is repeated correctly, two points if there is one mistake, one point if there are two mistakes and zero if there are three or more mistakes. The maximum score is 48.

The task resembles the Recalling sentences subtest of CELF (Semel, Wiig, & Secord, 1996), in that the child is asked to repeat verbatim sentences of increasing length and complexity and responses are scored in relation to the number of errors made in each sentence.

3.4.2 The Renfrew language scales

3.4.2.1 The Word Finding Vocabulary Test (Renfrew, 1995)

Vocabulary is considered to be one of the powerful indicators of language development, related to the accuracy of verbal representations. Vocabulary production is assessed as a general measurement of language development. It can provide information on the development of stored linguistic knowledge i.e. for the accuracy and adequacy of phonological, semantic and motoric information that a child is able to access in order to name a picture.

The Word Finding Vocabulary Test (Renfrew, 1988) is a test of vocabulary production for children aged 3 – 9 years. Black and white line drawings are presented for the child to produce a spoken response. Items are arranged in order of progressively increasing difficulty. Assessment discontinues after six consecutive incorrect responses. The task has been fully standardized in Greek language (Vogindroukas, Protopapas, & Sideris, 2009). Pictures in the Greek version were re-arranged in order of difficulty and a cut-off criterion of five instead of six is used. Norms (mean and standard deviation) are available for children aged 4;0 – 8;0 years. The maximum score is 50.

3.4.2.2 The Action Picture Test (Renfrew, 1997)

The appropriate use of morphology is associated with agreement between the various terms found in a sentence. To study the development of morphology it is important to assess the proper production of morphemes in complete, grammatically correct sentences. DVIQ is a comprehensive evaluation of morphosyntax; however, it requires the completion of a sentence. The initial part of the sentence is said by the examiner in order to elicit from the child the production of a particular structure which completes the sentence. In the event that a child is not capable of producing the requested morphosyntactic structure, the child may not be able to produce a simpler structure that reflects its linguistic capacity, as the model given by the examiner restricts the child's options for the completion of the sentence.

For this reason, two assessments of morphological production in context are used. The DVIQ production subtest (Tsimpli & Stavrakaki, 2001) is used to assess, in sentence completion, the potential for the production of complex morphosyntactic structures that a child may possibly not use spontaneously. Additionally, the Action Picture Test (Vogindroukas, Stavrakaki, & Protopapas, 2011) makes it possible to study, in elicitation, the spontaneous production of morphemes and to assess the child's ability to form complete and grammatically correct sentences.

The Action Picture Test (Renfrew, 1988) is a test of elicited sentence production for children aged 3 – 8 years. Colourful pictures accompanied by a simple question are used to stimulate the production of spoken language. The collected sample is analysed in terms of information given and the grammatical structures used. The task has been fully standardized in Greek (Vogindroukas, Stavrakaki, & Protopapas, 2011) for children aged 4; 0 – 7; 0 years and raw scores as well as percentile scores are available. Scoring is adapted to the characteristics of the Greek language, for example subject verb agreement is scored. The maximum score for Grammar is 66 and for Information is 50.

3.4.2.3 The Bus Story Test (Renfrew, 1997)

In order to study the language development of children it was considered useful to have a challenging assessment of spontaneous speech, combining requirements for proper use of grammar, syntax, and semantics. The Bus story test (Renfrew, 1997) is an assessment of language in a connected narrative for children aged 3 – 8 years of age. The child listens to a story said by the researcher while looking at some accompanying pictures representing the activities. Then the child is asked to look at the same pictures and narrate the story. The ability to give a coherent description of a continuous series of events is analysed in terms of content and grammatical accuracy. The child's story is scored according to the amount of accurate information given, the mean length of utterance and the use of subordinate clauses. Although the test standardization in Greek is not yet available, a pilot adaptation to the Greek language (Sgourdou, 2005) was chosen to investigate the spontaneous production of morphology in a task that is challenging as it requires the production of a narrative.

3.4.3 Athena Test, Assessment of Learning Difficulties

The Athena test (Paraskevopoulos et al. 1999) is a test battery designed to assess the learning abilities of children aged 5; 0 – 9; 11 years old. Age equivalent scores are available. The battery consists of eleven subtests. One of these, the phoneme blending subtest, is used for the present study.

3.4.3.1 Phoneme blending subtest:

The assessment of phonological awareness was considered important for the overall investigation of phonological development at different stages, with regard to both input and output. The published assessment of phoneme blending was used to assess children's ability to synthesize individual components heard into a single word, as a measurement of speech processing skills development. The test is used in order to assess the ability to compose words from the component individual phonemes. Moreover, in order to identify the picture corresponding to the auditorily presented stimulus, access to acurate representations is required. Thus the task addreses level E of the speech processing profile 'Are the child's phonological representations accurate?' It is considered that the assessment of phonological awareness skills contributes to our understanding of the development of speech processing skills.The same words were used on an experimental task of phonological awareness in terms of production, i.e. the segmentation of a word heard to individual units that compose it (presented in section 3.6).

Materials: a picture book with four pictures on each page in a horizontal order is given to the child.

Stimuli: Each picture illustrates a two or three syllable word with varying phonotactic structures (CV, CCV, CVC, or V). The complete set of stimuli can be found in Appendix 4.

Description of the task: This is a silent blending task. According to the test manual two practice items are given at the beginning of the assessment followed by ten test items. The experimenter says the phonemes of the target word one by one, pronouncing two phonemes per second. The child has to choose the corresponding picture by pointing. For example the child hears /p/-/u/-/l/-/i/ and is expected to point to [puˈli] (bird) in a series of four pictures. For each correct picture choice the child is given one point for blending at the phoneme level. The maximum score is 10.

Administration: For the purpose of the current study the mode of presentation had to be adapted, given that Group 1 participants were aged 3; 0 – 3; 6 at T1 of the study and according to the literature single phoneme blending skills have not been developed at this age. Therefore, practice items were presented at a single phoneme level, for example /p/-/u/-/l/-/i/ but if the children were not able to understand the task, practice items were presented in a syllable level, for example /pu/-/li/. For test items, the phoneme presentation was initially given. In case that a child failed to choose the correct picture at a second attempt a syllable presentation was given for the same item.

Scoring: Responses were scored for the correct picture selection. When a child chose the correct picture based on phoneme presentation of the target a point (1) was given (maximum score 10). When a child chose the correct picture based on syllable presentation of the target, a half point (0.5) was given (the maximum score possible for accurate picture choice for all task items following a syllable presentation is therefore 5). Given that the final score may represent performance accuracy for syllable presentation of some stimuli and phoneme presentation of other stimuli, a score of more than five indicates that the child was able, at least for some of the task items, to blend phonemes. However, it is possible that a child who scored less than five, was successful in phoneme blending with some items while failing even to achieve syllable blending with some other items.

3.5 Experimental stimuli

3.5.1 Stimuli of morphological interest

3.5.1.1 Morphological minimal pairs

DVIQ comprehension and production subtests are used as a baseline assessment of language, as these tasks have been widely used in research, allowing the assessment of a considerable number of items representative for the Greek language phenomena of morphology and syntax. Although these two subtests are components of the same assessment tool, their focus is not exactly on the same grammatical phenomena. The comprehension subtest consists mainly of questions that assess differences in tense or voice of verbs while the production subtest aims to elicit the correct formation of pronouns and nouns in terms of case and number. In addition it is not clear in both subtests whether the child can adequately distinguish between the target and the alternative - similar option. The comprehension subtest requires a choice between three pictures where at least one is morphologically related to the target. For the assessment of language production the child is presented with two pictures at a time, given the Task description of one of them and based on that open ended phrase is asked to complete the Task description of the second. It could be the case that the child neither understands nor is able to produce the element that was used. Certain stimuli included in DVIQ, either in Comprehension or in Production subtests, were chosen to be used in a more systematic way in devising experimental tasks that would make use of these stimuli both in comprehension and production modalities.

In order to ensure that exactly the same stimuli are used across modalities, so that performance can be directly compared, and that children are able to understand and produce the morphemes of interest, an experimental test was devised. Stimuli that were originally assessed in the production task were assessed in comprehension experimental task and *vice versa* stimuli that were originally assessed in the comprehension task were assessed in production experimental task. Furthermore certain morphemes that were originally used as distracters either in comprehension of production task were assessed in comprehension and production experimental tasks. Experimental tasks include:

1. Comprehension of certain morphemes that were originally assessed in production.
2. Production of certain morphemes that were used in open ended phrases in order to elicit the production of the target morphemes.
3. Production of morphemes that were originally assessed in comprehension
4. Comprehension of certain morphemes that were used as a distractor to the target morpheme in comprehension task.

The selected stimuli can be seen in Table 3-2. The modality in which they are used in experimental tasks can be seen in the heading of each column. The original function of those stimuli within the DVIQ test battery can be seen in parenthesis.

Table 3-2 Morphological stimuli

Comprehension (originally in production)	Production (originally in open ended phrase)	Production (originally in comprehension)	Comprehension (alternative choice)
[zoˈɐci tis] *Her pet*	[zoˈɐci tu] *His pet*	[koˈlibun] *are swimming*	[koliˈbisun] *will go swimming*
[sɛɐˈftin] *to her*	[sɛɐˈfton] *to him*	[tɐˈizun] *are feeding*	[tɐˈisun] *will feed*
[tonɛɐˈftɐtu] *Himself*	[tonɛɐˈftɐtis] *herself*	[ˈðini] *gives*	[ˈɛðosɛ] *Gave*
[tisˈɣɐtɛs] *Cats*	[tiˈɣɐtɐ] *Cat*	[θɐ ˈfɐi] *Will eat*	[ˈɛfɐjɛ] *Ate*
[ˈvjicɛ] *Got out*	[ˈvɣɛni] *Gets out*	[cimiˈθi] *to sleep*	[ciˈmɐtɛ] *is sleeping*
[ziˈjizodɛ] *they are weighted*	[ziˈjizɛtɛ] *it is weighted*	[pɛˈtɐi] *flies*	[ˈpɛte͡ksɛ] *Flew*
[mɐˈnɐviðɛs] *grocery men*	[mɐˈnɐvis] *grocery man*	[ɐgɐˈʎɐzodɛ] *are hugging*	[ɐgɐˈʎɐzi] *is hugging*

The selected stimuli aim to assess the comprehension and production of morphemes as being used to manifest differences in gender of pronouns (5), number of nouns (2) and verbs (2), future (4) and past (3) tense in verbs and voice (1). Therefore 15 morphologically different pairs were arranged in two blocks, so that only one of them would appear in each of the tasks. These stimuli are used in language comprehension and production supplementary tasks, Real Word Auditory Discrimination, and RW Repetition task. The complete set of novel stimuli arranged in two blocks and the different function of each can be seen in Table 3-3.

Table 3-3 Morphological minimal pairs

Morphological function	Block A	Block B
Pronoun Masculine vs femine	[zoˈɐci tis] *her pet*	[zoˈɐci tu] *His pet*
	[sɛɐˈftin] *to her*	[sɛɐˈfton] *to him*
	[tonɛɐˈftɐtu] *himself*	[tonɛɐˈftɐtis] *herself*
Number Single vs Plural	[ˈɣɐtɐ] *Cat*	[ˈɣɐtɛs] *Cats*
	[mɐˈnɐviðɛs] *grocery men*	[mɐˈnɐvis] *grocery man*
Verb 3rd person Singular vs plural	[ziˈjizodɛ] *they are weighted*	[ziˈjizɛtɛ] *it is weighted*
	[ɐgɐˈʎɐzodɛ] *are hugging*	[ɐgɐˈʎɐzi] *is hugging*
Verb tense Present vs. future	[tɐˈizun] *are feeding*	[tɐˈisun] *will feed*
	[koliˈbisun] *will go swimming*	[koˈlibun] *are swimming*
	[ˈpɛzi] *plays*	[ˈpɛksi] *play*
	[θα ˈfɐi] *Will eat*	[ˈɛfɐʝɛ] *ate*
	[ciˈmɐtɛ] *is sleeping*	[cimiˈθi] *to sleep*
Verb tense Present vs. past tense	[ˈðini] *gives*	[ˈɛðosɛ] *gave*
	[ˈpɛtɐksɛ] *flew*	[pɛˈtɐi] *flies*
	[ˈvjicɛ] *Got out*	[ˈvɣɛni] *Gets out*

Since detailed information is not available for the development of different grammatical elements in Greek, using DVIQ stimuli in speech processing tasks controls for factors such as age of acquisition, frequency of the grammatical element, difficulty in terms of language comprehension and production. It allows investigation in parallel of (a) the development of linguistic knowledge in terms of language comprehension and production and (b) the development of speech input and output processing skills for the comprehension and production of certain phenomena of interest such as morphemes marking gender, number, person and tense.

3.5.1.2 Non-words matched to morphological minimal pairs.

Two morphemes may change the grammatical function of a word e.g. present versus future tense. These morphemes need to be phonologically distinct, for example in the pair of [tɐˈizun] (*are feeding*) and [tɐˈisun] (*will feed*) the phonological contrast of /s/-/z/ is essential to manifest the meaning of present in contrast to future tense. Morphological minimal pairs are not necessarily phonological minimal pairs as in this example. However, in order to assess if children are able to discriminate and produce the phonological properties that are related to the experimental stimuli of morphological interest, even if they do not yet have knowledge of the two morphemes, a set of matching nonwords was created. In order to create these nonwords the stressed vowel of the real word was changed e.g. from the real words [zoˈɐci tis] *(her pet)* vs. [zoˈɐci tu] *(his pet)* the nonwords /zoˈɛci tis/ vs. /zoˈɛci tu/ were created. When the stress was located on the target morpheme, as in the case of [sɛɐˈftin] (*to her*) vs. [sɛɐˈfton] (*to him*) then one other vowel was changed, so in this case the non- words / sɛoˈftin/ vs. / sɛoˈfton/ were created. These stimuli are used in Nonword auditory discrimination and NW repetition task. The complete set of nonwords that are based on morphological stimuli can be seen in Table 3-4.

Table 3-4 Nonwords matched to stimuli of morphological interest

Block A	Block B
zoˈɛci tis	zoˈɛci tu
sɛoˈftin	sɛoˈfton
tonɛɐˈftɐtu	tonɛɐˈftɐtis
ˈɣotɐ	ˈɣotɛs
mɐˈnoviðɛs	mɐˈnovis
ziˈɣɐzɛtɛ	ziˈɣɐzodɛ
ɐgɐˈʎɛzodɛ	ɐgɐˈʎɛzi
tɐˈɛzun	tɐˈɛsun
kɐliˈbisun	kɐˈlibun
ˈpɐzi	ˈpɐksi
θɐˈfoi	ˈɛfojɛ
ciˈmɛtɛ	cimɛˈθi
ˈðuni	ˈɛðusɛ
ˈpɛtoksɛ	pɛˈtoi
ˈvʝiku	ˈvɣenu

3.5.2 Stimuli of phonological interest

3.5.2.1 Phonological minimal pairs

In order to assess the speech sound processing abilities of the children, a number of phonological minimal pairs were chosen. Initially a list of phonological minimal pairs was created. It was estimated that 40 of those pairs were familiar to young children and could be illustrated with pictures. The phonological properties of the words such as voicing, manner and place of articulation and the phonotactic structure such as consonant clusters or close syllables were taken into consideration, in order to ensure broad representation of the Greek phonological system. A pilot assessment of those pairs was done with a small group of children to ensure that stimuli are properly illustrated and recognisable by young children. Finally 15 pairs were chosen to be used. The phonological minimal pairs were divided into two phonologically contrasting blocks. These stimuli are used in RW Auditory Discrimination ABX task, RW Auditory Discrimination with picture choice task and RW Repetition task. In Auditory Discrimination with picture choice, four pictures were presented, two representing the phonological minimal pair stimuli and two distractors, each semantically related to one of the stimuli of phonological interest. The complete set of stimuli can be seen in Table 3-5.

Table 3-5 Phonological minimal pairs

	Block A	Block B	A Distractor	B Distractor
voicing	[ku ˈbi] *button*	[ku ˈpi] *paddle*	*zipper*	*boat*
	[ˈxomɐ] *soil*	[ˈ ɣomɑ] *eraser*	*rocks*	*pencil*
place	[tɐ'ksi] *taxi*	[tɐ'psi] *pan*	*bus*	*frying pan*
	['θici] *case*	['fici] *seaweed*	*cloth*	*fish*
	[jɐˈʎɐ] *glasses*	[jɐˈjɐ] *grandmother*	*headphones*	*grandfather*
	[kɐlɐ'mɐcɐ] *straws*	[pɐlɐ'mɐcɐ] *clapping*	*glass*	*laughing*
	['çɛri] *hand*	['çɛli] *eel*	*leg*	*frog*
	[ˈɲifi] *bride*	[ˈɲiçi] *nail*	*broom*	*finger*
metathesis	['ðrɐci] *dragons*	['ðɐkri] *tear*	*witches*	*exhaustion*
	[kɐ'vuri] *crab*	[ku'vɐri] *skein of thread*	*turtle*	*knitting*
Cluster reduction	['sfikɐ] *wasp*	['sikɐ] *figs*	*butterfly*	*apples*
	['supɐ] *soup*	['skupɐ] *broom*	*omelette*	*dust pan*
	['stomɐ] *mouth*	['somɐ] *body*	*nose*	*head*
	['xomɐtɐ] *soil*	['xromɐtɐ] *colours*	*pebbles*	*black-white*
	['ɣrɐfi] *writing*	['rɐfi] *shelf*	*cutting*	*closet*

3.5.2.2 Nonwords based on phonological minimal pairs

In order to assess speech sound processing abilities when linguistic knowledge is not available a set of matching nonwords was created. The stressed vowel of the real word was changed to create a matching nonword. As in Greek there are only five vowels there was one case where the stressed vowel could not be changed without creating another real word so it was another vowel that was changed. These stimuli are used in nonword auditory discrimination and NW Repetition task. The complete set of nonword minimal pairs can be seen in Table 3-6.

Table 3-6 Nonwords matched on phonological minimal pairs

	Block A	Block B
voicing	cɛ ˈbi	cɛˈpi
	ˈ xumɐ	ˈ ɣumɑ
place	tɐˈkso	tɐˈpso
	ˈθɛci	ˈfɛci
	jɐˈʎo	jɐˈjo
	kɐlɐˈmɛcɐ	pɐlɐˈmɛcɐ
	ˈçuri	ˈçuli
	ˈɲɛfi	ˈɲɛçi
metathesis	ˈðroci	ˈðokri
	rɐˈvuci	ruˈvɐci
Cluster reduction	ˈsfɛkɐ	ˈsɛkɐ
	ˈsɐpɐ	ˈskɐpɐ
	ˈstɐmɐ	ˈsɐmɐ
	ˈxɐmɐtɐ	ˈxrɐmɐtɐ
	ˈɣrufi	ˈrufi

3.5.2.3 Polysyllabic words

Seven polysyllabic words that are included in the Renfrew word finding test are used in the Mispronunciation Judgment task and the RW Repetition task

3.5.2.4 Mispronunciation Detection of polysyllabic words

Three erroneous productions of each polysyllabic word are used in a Mispronunciation Detection task. They derive from commonly heard childhood productions; there is a variety of mistakes from gross to fine grained mismatches reflecting phonological processes from syllable deletion to cluster reduction and final consonant transposition. The aim is to track developmental changes in accuracy of stored phonological representations for polysyllabic words. The complete set of stimuli can be seen in Table 3-7.

Table 3-7 Stimuli included in Mispronunciation detection task

Block A			Block B		
Picture	Stimulus	Judgment	Picture	Stimulus	Judgment
crocodile	koˈkoðilos		crocodile	[kroˈkoðilos]	correct
crocodile	koˈkovilos		crocodile	korˈkoðilos	
helicopter	εliˈkoptεlo		helicopter	[εliˈkoptεro]	correct
helicopter	[εliˈkoptεro]	correct	helicopter	εliˈkotεlo	
kite	xɐtɐεˈtos		kite	[xɐrtɐεˈtos]	correct
kite	xɐxɐtεˈos		kite	xɐεˈtos	
microphone	[miˈkrofono]	correct	microphone	miˈkofono	
microphone	miˈfofono		microphone	miɾˈkofono	
parachute	[ɐlεˈksiptoto]	correct	parachute	ɐlεˈsitoto	
parachute	ɐlεˈtsitoto		parachute	ɐlεˈpsiptoto	
snail	sɐliˈgɐli		snail	θɐliˈgɐli	
snail	ɐsliˈgɐri		snail	[sɐliˈgɐri]	correct
thermometer	θrεˈmomεto		thermometer	θeˈmometo	
thermometer	[θεrˈmomεtro]	correct	thermometer	feˈmometo	
crocodile	[kroˈkoðilos]	correct	parachute	[aleˈksiptoto]	correct

3.5.2.5 Nonwords based on polysyllabic words

Based on the seven real polysyllabic words a set of nonwords was created. Given the length of the word two vowels were changed in order to minimize resemblance to the real word. In case of compound words, a vowel was changed in each component element. These stimuli are used in the nonword repetition task. The set of nonwords can be seen in Table 3-8.

Table 3-8 Nonwords based on real polysyllabic words

English stimulus from Renfrew WFS	Greek stimulus real-word	Nonword for NWR
kite	xɐrtɐεˈtos	xortɐεˈtɐs
snail	sɐliˈgɐri	sεliˈgori
helicopter	εliˈkoptεro	εliˈkɐptεro
crocodile	kroˈkoðilos	krεˈkɐðilos
microphone	miˈkrofono	miˈkrεfono
thermometer	θεrˈmomεtro	θεrˈmεmotro
parachute	ɐlεˈksiptoto	ɐlεˈkseptɐto

3.5.2.6 Stimuli for segmentation task

In order to assess the ability to segment words into constituent syllables or phonemes children were asked to complete an experimental task of word segmentation. Stimuli were derived from the blending subtest of Athina test and the polysyllabic words used in experimental tasks. The aim was to assess the ability to manipulate constituent components of words of 2-3 syllables and polysyllabic words. The list of stimuli can be seen in Table 3-9.

Table 3-9 Segmentation task stimuli

Block A			Block B	
puˈli	*Bird*		xɐrtɐɛˈtos	*Kite*
buˈkɐli	*bottle*		sɐliˈgɐri	*snail*
kɐˈrɐvi	*ship*		ɛliˈkoptɛro	*helicopter*
ɐˈstɛri	*star*		kroˈkoðilos	*crocodile*
viˈvlio	*book*		miˈkrofono	*microphone*
pɐˈputsi	*shoe*		θɛrˈmomɛtro	*thermometer*
ɛˈlɐfi	*deer*		ɐlɛˈksiptoto	*parachute*
ˈvɐrkɐ	*boat*			
ˈskɐlɐ	*ladder*			
spɐˈθi	*Hammer*			

3.5.2.7 Stimuli for STM task

In order to assess the ability to repeat words in word chunks, six blocks of words, each one of which contains six series of words are used. The first block consists of two words per series; one word is added to each of the next blocks. In order to eliminate the effect of articulatory demands on performance it was decided to keep word structure as simple as possible therefore two and three syllable words of CV structure are used. In order to ensure that familiarity is not affecting performance, stimuli found to be familiar to preschool age children (Papathanasiou, Varla, Kourakos, & Spadideas, 2004) were used. The complete set of stimuli can be seen in Table 3-10

Table 3-10 STM stimuli

	Number of Syllables in each word	Chunk Total number	Stimuli
2 words	2 + 2	4	'milo – 'bɐlɐ
	2 + 3	5	'zoni – bɐ'nɐnɐ
	3+ 3	6	pi'nɛlo – kɐ'roto
	2 + 2	4	pu'li – 'lɐbɐ
	2 + 3	5	'filo - kɐro'to
	3+ 3	6	lu'luði - fɛ'gɐri
3 words	2 +2 + 2	6	'roðɐ - 'fiði - cɛ'ri
	2 + 2 + 3	7	'botɐ- 'milo - 'mɐti
	2 + 3 + 3	8	'ɣɐtɐ - ɣu'runi - lɛ'moni
	3 + 3 + 3	9	po'tiri - pɐ'putsi - ʎo'dɐri
	2 +2 + 2	6	cɛ'ri - 'çiʎi – jɐ'ʎɐ
	2 + 2 + 3	7	'milo – 'poði - kɐro'to
4 words	2 + 2 + 2 + 2	8	'çiʎi – jɐ'ʎɐ – 'milo - 'lɐbɐ
	2 + 2 + 2 + 3	9	'botɐ - 'psɐri – mɐti – çɛ'lonɐ
	2 + 3 + 2 + 3	10	'roðɐ - ku'tɐli - 'fiði - psɐ'liði
	3 + 2 + 3 + 3	11	fɛ'gɐri - po'dici -'lɐbɐ - ɣu'runi
	3 + 3 + 3 + 3	12	pɐ'putsi - ku'tɐli - çɛ'lonɐ - fɛ'gɐri
	2 + 3 + 3 + 2	11	jɐ'ʎɐ – pi'nɛlo – kɐ'roto – 'mɐti
5 words	2 + 2 + 2 + 2 + 2	10	'botɐ - 'psɐri – 'milo – 'çɛri - pu'li
	2 + 2 + 2 + 2 + 3	11	'roðɐ -'ɣɐtɐ - 'fiði - cɛ'ri -po'tiri
	2 + 3 + 2 + 3 + 2	12	cɛ'ri - po'dici - 'milo - kɐro'to - 'mɐti
	3 + 2 + 3 + 2 + 3	13	psɐ'liði - pu'li – fɛ'gɐri - 'lɐbɐ - kɐ'roto
	3+ 2 + 3 + 3 + 3	14	po'tiri – mɐti - fɛ'gɐri - ɣu'runi - ku'tɐli
	3 + 3 + 3 + 3 + 3	15	kɐ'roto - pɐ'putsi - ʎo'dɐri - pi'nɛlo – kɐ'roto
6 words	2 + 2 + 2 + 2 + 2 + 2	12	'milo – 'roðɐ - 'fiði - cɛ'ri - 'bɐlɐ -'ɣɐtɐ
	2 + 2 + 2 + 2 + 2 + 3	13	'botɐ - 'psɐri – - 'çiʎi – jɐ'ʎɐ - 'milo – çɛ'lonɐ
	2 + 2+ 3 + 3 + 2 + 2	14	'zoni - 'lɐbɐ - pɐ'putsi - ʎo'dɐri - 'fiði - cɛ'ri
	2 + 3 + 2 + 3 + 2 + 3	14	'ɣɐtɐ - ɣu'runi - 'psɐri - lɛ'moni -'poði - kɐro'to
	2 + 3 + 2 + 3 + 3 + 3	16	'mɐti - bɐ'loni - 'milo - pɐ'putsi - çɛ'lonɐ - fɛ'gɐri
	2 + 3 + 3 + 3 + 3 + 3	17	'roðɐ - lɛ'moni - lu'luði - ku'tɐli - psɐ'liði - bɐ'nɐnɐ
7 words	2 + 2 + 2 + 2 + 2 + 2 + 2	14	'milo – 'bɐlɐ – 'zoni - pu'li – 'mɐti – 'botɐ - cɛ'ri
	2 + 2 + 2 + 2 + 2 + 2 + 3	15	'çɛri - 'filo – jɐ'ʎɐ – 'lɐbɐ – 'psɐri - cɛ'ri - ɣu'runi
	3 + 2 + 2 + 2 + 2 + 2 + 3	16	çɛ'lonɐ - jɐ'ʎɐ - 'milo - 'ɣɐtɐ -'lɐbɐ - fɛ'gɐri - 'fiði
	3 + 2 + 2 + 3 + 2 + 2 + 3	17	ku'tɐli - 'milo – 'çiʎi - çɛ'lonɐ – 'zoni - pu'li - fɛ'gɐri
	3 + 3 + 2 + 2 + 2 + 3 + 3	18	lɛ'moni - ʎo'dɐri - 'poði – 'fiði – 'roðɐ - pɐ'putsi - ku'tɐli
	3 + 3 + 2 + 3 + 2 + 3 + 3	19	pɐ'putsi - çɛ'lonɐ - 'roðɐ - ku'tɐli -'poði - kɐro'to - ɣu'runi

3.6 Experimental tasks

3.6.1 Assessment of language production (supplementary blocks)

Description of the task: it is a picture based assessment. For each picture, an open ended phrase is designed to trigger the production of morphological phenomena that either have already been tested in DVIQ comprehension or were used as a carrier phrase in the DVIQ production task. The child looks at the pictures, the experimenter points to one of them, says an open ended phrase that describes it; then points to another picture and waits for the child to complete the rest of the phrase in order to describe properly the second picture. For example original DVIQ production task included the carrier phrase '*this is her pet and this one is …*' in order to elicit the production of *'his pet'*. In the experimental task the phrase was used in the opposite direction i.e. *'this is his pet and this one is…'* in order to elicit the production of *'her pet'*. This way production of both morphemes [zoˈɐci tis] *(her pet)* and [zoˈɐci tu] *(his pet)* was targeted either in the experimental stimuli or in the original DVIQ stimuli.

Materials: Pictures were presented using Powerpoint on a laptop computer. The researcher would point to each picture while speaking. The complete set of stimuli used is presented in section 3.5.1.1

Scoring: the child is given one point for each correct answer; it is noted if there is an incorrect or no answer to a question.The maximum score is 26

3.6.2 Assessment of language comprehension (supplementary blocks)

Description of the task: it is a picture based assessment of several morphological phenomena that either have already been assessed in the DVIQ production test or are closely related to a target that was assessed in the DVIQ comprehension test. Following the format of DVIQ comprehension the pictures are shown to the child, the experimenter points to all of them, says the command and waits until the child points to the relevant picture.

Materials: Pictures were presented using Powerpoint on a laptop computer. Pictures from comprehension and production modalities were presented in random order. The complete set of stimuli used is presented in section 3.5.1.1

Scoring: the child is given one point for each correct answer; it is noted if there is an incorrect or no answer to a question. The maximum score is 23

3.6.3 Nonword auditory discrimination

Description of the task: The task is used in order to assess a child's ability to discriminate similar sounding pairs of non-words from auditory presentation only. It is an input processing task that neither requires nor allows access to stored lexical representations. The task is used to address level B of the speech processing profile 'Can the child discriminate speech sounds without reference to lexical representations?'. Performance on the task provides information on whether children can discriminate speech sounds related to (a) phonological elements and (b) morphological elements of the Greek language without reference to phonological and morphological representations respectively.

Materials: It is a computer task. There is a large space-ship at the top of the screen, with two smaller space ships below. An alien appears in the top space ship and says a non-word 'X', for example /'θεci/. An alien appears in the lower left hand ship and says a non-word 'A', for example /'θεci/. An alien appears in the right hand space ship and also says a non-word 'B', for example /'fεci/. The child's task is to click on the alien in one of the smaller space ships who matched the alien in the top space ship (i.e. whether A or B was the same as X). Then the aliens disappear. A prompt is given before the presentation of each pair and corrective feedback is provided in the case of a wrong answer to maintain the child's attention. Aliens are used to indicate that the auditory stimuli are not real words that the child could expect to recognize. The ABX computer paradigm enables the assessment of young children who have difficulty with the concept of same/different as it can be explained to the child without using those words. Being an amusing, interactive computer game helps children who have difficulty in focusing their attention to concentrate. However, it requires that three nonwords remain in short – term memory. Greater demand on short – term memory skills could affect a child's performance. Comparing performance on the ABX non-words task with performance on ABX real words task with matched stimuli may be useful to indicate if a child can discriminate between unfamiliar words i.e. new vocabulary or if the ability to discriminate between sounds depends on existing lexical representations. Comparison of performance on this task with performance on speech production tasks with matched items may be useful to indicate whether a child's speech production errors are reflecting an auditory discrimination difficulty. The complete set of stimuli used is presented in section 3.5.2.2.

Scoring: is automatically done by the computer. The child is given one point for each correct choice at first attempt. The maximum score is 30.

3.6.4 Real word auditory discrimination

Description of the task: To assess a child's ability to discriminate similar sounding pairs of words from auditory presentation only. It is an input processing task that allows access to stored lexical representations. Since the stimuli used are real words, (in contrast to nonword stimuli used in the previous task) it is possible for the child to use stored knowledge in order to complete the task. The task is used to address level D of the speech processing profile 'Can the child discriminate between real words?'. Performance on the task provides information on whether children can discriminate between words with (a) different phonological elements and (b) different morphological elements of the Greek language, when stored linguistic knowledge may be used to support performance.

Materials: It is a computer task. There is a large space-ship at the top of the screen, with two smaller space ships below. A girl appears in the top space ship and 'says' a word 'X' for example [ˈkupɐ] *(cup)*. A second girl appears in the lower left hand ship and says a word 'A' for example [ˈkupɐ] *(cup)*. A third girl appears in the right hand space ship and also says a word 'B' for example [ˈskupɐ] *(broom)*. The child's task is to click on the girl in one of the smaller space ships who matched the girl in the top space ship (i.e. whether A or B was the same as X). Then the girls disappear. A prompt is given before the presentation of each pair and corrective feedback is provided in the case of a wrong answer to maintain child's attention. Girls are used to indicate that auditory stimuli are real words that the child could expect to recognize. The complete set of stimuli used is presented in section 3.5.2.1.

Scoring: is automatically done by the computer. The child is given one point for each correct choice at first attempt.The maximum score is 30.

3.6.5 Real word auditory discrimination with picture choice

Description of the task: to assess the precision of phonological representations without a verbal response being required. As real words are used, it is expected that the child has stored lexical knowledge about those words. Since the child is asked to choose the picture that corresponds to the word heard, it is necessary for the child to use the stored knowledge to make the right choice. The task is used to address level E of the speech processing profile 'Are the child's phonological representations accurate?'. Performance on the task provides information on whether children have access to accurate phonological representations. Auditory discrimination with picture choice for morphological elements is not assessed, because this is a single word task. There is the risk that the single-word presentation will not convey all the information found in phrases such as subject - verb agreement; children will not therefore have all the necessary information to make use of the morphological representations in order to respond correctly. The supplementary blocks of language comprehension (presented in section 3.5.1.1) are used to provide information on whether children can accurately discriminate between morphemes conveying different meaning (for example masculine as opposed to feminine) within the context of a sentence.

Materials: It is a computer task. The child will see four pictures on the computer screen. Two of the pictures constitute a phonological minimal pair. Each of the other two is semantically related to one of the pictures (every time a child listens to a word and chooses between the target word, a phonological distractor, a semantic distractor and a fourth picture semantically related to the phonological distractor). The phonological distractor is used to evaluate how accurate the phonological representations are, regarding the constituent phonemes. If phonological representations are not sufficiently defined, the child may choose the phonological distractor, instead of the target word. The semantic distractor is used to evaluate how accurate the semantic representations are and how explicit are their links with phonological representations. If the connection between phonological form and semantics (meaning) is not sufficiently defined, the child may choose the semantic distractor, instead of the target word. The child sees all the pictures simultaneously, listens to the name of one of them and has to choose the correct one between the four. If the child makes the correct choice, reinforcement e.g. "well done" will be given and the next set of pictures will be presented. If the child chooses the wrong picture corrective feedback will be given. The complete set of stimuli used is presented in section 3.5.2.1.

Scoring is automatically done by the computer; child is given one point for each correct choice. The maximum score is 30.

3.6.6 Mispronunciation detection for polysyllabic words

Description of the task: it is a computer task designed to investigate the precision of phonological representations without a verbal response being required. It is specifically designed to assess the precision of phonological representations for polysyllabic words, that cannot be assessed with real word auditory discrimination with picture choice task, since minimal pairs for polysyllabic words hardly exist in Greek. Auditory discrimination with picture choice is used to assess the precision of phonological representations for words of 2 and 3 syllables. The child is asked to judge if a spoken word matches the name of the object shown on the screen. If the phonological form of the word has been stored precisely, the child does not accept the erroneous productions as the correct way to name the object shown. If the phonological form of the word is not sufficiently defined, the child can accept an erroneous production as correct for of the picture shown. The task is used to address level E of the speech processing profile 'Are the child's phonological representations accurate?'. Performance on the task provides information on whether children have access to accurate phonological representations, in particular for polysyllabic words that are frequently used in Greek.

Materials: The child sees a picture at the top on the computer screen and two children at the bottom; one of them "Mr. Right" is saying the words correctly while the other one "Mr. Wrong" is making mistakes. The child sees the picture of a word and listens to either a correct production or a mispronunciation; then is asked to decide if it was the correct name for that picture or not. If the child makes the correct choice reinforcement i.e. "well done" is given and the next picture is presented. If the child makes an erroneous judgment corrective feedback is given and the child has to decide again until the correct choice is made before being able to proceed. A block of practice items is used at the beginning. Stimuli are divided in two blocks, each containing five accurate productions and ten mispronunciations. The complete set of stimuli used is presented in section 3.5.2.4

Scoring is automatically done by the computer; the child is given one point for each correct judgment at first attempt. The maximum score is 30.

3.6.7 Real word repetition

Description of the task: it is a task designed to examine the child's ability to repeat words. When a real word is used in repetition, the child is able to use the stored linguistic information to reproduce the word heard. The productions of the child were both recorded and transcribed at the time of speaking. Real-time transcription was checked by referring to the recordings later. The task is used to address level I of the speech processing profile 'Can the child articulate real words accurately?'. Performance on the task provides information on whether children can produce words with (a) different phonological elements and (b) different morphological elements of the Greek language, when a model is given and stored linguistic knowledge may be used to support performance.

Materials: It is a computer task. In order to keep children interested and motivated scratch platform was used. Words were pre-recorded to ensure that all the participants would listen to the stimuli under exactly the same conditions with regard to rate, loudness and prosody. A cartoon that looks like a human being appears in an attractive background and says a word. Once the child repeats the word the cartoon moves a little bit or the background colour is changed and the next word is heard. Children are asked to complete two blocks of phonological stimuli (presented in section 3.5.2.1) one block of polysyllabic stimuli (presented in section 0) and two blocks of morphological stimuli (presented in section 3.5.1.1).

Scoring is done by the researcher a) for the number of words correct out of the total number of words and b) for the Percentage of Consonants Correct (PCC). The maximum score is a) 30 and b) 100%.

3.6.8 Nonword repetition

Description of the task: it is a task designed to examine the child's ability to repeat nonwords. When a nonword is used in repetition, the child is not able to use stored linguistic information to reproduce what was heard. Therefore, it is necessary for the child to use motor programming skills to generate a new motor program. The productions of the child were both recorded and transcribed at the time of speaking. Real-time transcription was checked by referring to the recordings later. The task is used to address level J of the speech processing profile 'Can the child articulate speech without reference to lexical representations?'. Performance on the task provides information on whether children can produce sounds related to (a) phonological elements and (b) morphological elements of the Greek language without reference to phonological and morphological representations respectively.

Materials: It is a computer task. In order to keep children interested and motivated scratch platform was used. Nonwords were pre-recorded to ensure that all the participants would listen to the stimuli under exactly the same conditions (rate, loudness, prosody). An animal cartoon e.g. a parrot, a monkey appears on the screen; animals are used to indicate that auditory stimuli are not real words that the child could expect to recognize. The cartoon says a word for the child to repeat. Once the child repeats it, the cartoon moves a little bit or the background colour is changed and the next word is heard. Children are asked to complete two blocks of nonwords matched on phonological stimuli (presented in section3.5.2.2) one block of nonwords matched on polysyllabic stimuli (presented in section3.5.2.5) and two blocks of nonwords matched on morphological stimuli (presented in section 3.5.1.2).

Scoring is done by the researcher a) for the number of nonwords correct out of the total number of nonwords and b) for the Percentage of Consonants Correct (PCC). The maximum score is a) 30 and b) 100%.

3.6.9 Segmentation task

Description of the task: The task is used to investigate the ability to reflect on phonological representation with a verbal response being required. In order to assess the ability to segment words into constituent syllables or phonemes, i.e. to reflect on component units of words, children were asked to complete an experimental task of word segmentation. A word is given orally for example /buˈkɐli/ and the child is asked to segment this word into constituent parts. The task is used to address level H of the speech processing profile 'Can the child manipulate phonological units?'. Performance on the task provides information on whether the child can segment real words into constituent parts. In order to succeed the child has to be aware of the component units and also to produce them one by one. It is considered that the assessment of phonological awareness skills contributes to our understanding of the speech processing skills development.

Materials: The complete set of target words that are used in the Athena blending test (presented in section 3.4.3.1) and the polysyllabic words (presented in section 0) are used. The complete set of task items can be seen in Table 3-9.

Administration: In order to introduce the task the experimenter uses the child's name; the child is asked to say its name cut in small pieces. To exemplify the segmentation of words into constituent parts, it is compared to a small frog jumping and yelling. Each jump corresponds to a phoneme or syllable. If the child is not able to understand the concept of segmentation, the therapist provides a model of the child's name being segmented. Then two practice items are given at the beginning of the assessment followed by seventeen test items.

Scoring: In order to differentiate between the children who are able to segment at the phoneme level from those who are able to segment at the syllable level, for each tested item children are given a score on graded scale. Points are given depending on whether words are fully (2 points) or partially (1 point) analyzed and whether the segmentation is at the level of phoneme (2 points) or syllable (1 point). Therefore scoring is as follows:

- Zero point for no segmentation of the target for example /buˈkɐli/
- One point for some segmentation of the target into constituent syllables for example /bu/-/ˈkɐli/

- Two points for proper segmentation of the target into constituent syllables for example /bu/-/ˈkɐ/-/li/
- Three points for some segmentation of the target into constituent phonemes for example /bu/-/ˈkɐ/-/l/-/i/ or /bu/-/u/-/ˈkɐ/-/ɐ/-/li/-/i/
- Four points for proper segmentation of the target into constituent phonemes for example /b/-/u/-/k/-/ɐ/-/l/-/i/

A score of less than 17 indicates that some of the task items were not segmented at all. A score above 17 indicates that all task items were segmented, at least partially in syllables. A score of more than 34 indicates at least partial segmentation in phonemes. A maximum score of 68 indicates that all the items were accurately segmented into constituent phonemes.

3.6.10 Short term memory (STM) test

Description of the task: In order to assess children's ability to recall words in the right order without processing the verbal mater i.e. in order to assess the phonological loop component of STM (presented in section 1.6.2) a test of STM was devised based on the Working Memory Test Battery for children (WMTB-c, Gathercole & Pickering, 2001).

Material: a computer presentation was used. Stimuli were pre – recorded so that each word would be heard 2 seconds after the beginning of the previous one. An interval of 2 seconds instead of 1 that is used in WMTB-c was chosen to take account of words of 3 syllables. The complete set of stimuli used is presented in section 3.5.2.7. Two practice items are presented at the beginning of the assessment. Subsequently the child listens to the words of the first block. If the child is able to recall four sets of words then assessment moves on to the next block. If the child fails to repeat at least three sets of words in a block the assessment is terminated.

Scoring: the child is given one point for each word set correctly recalled. When assessment moves on to the next block as a result of accurate repetition of four sets of words, credit is given for the sets that were omitted in this block. The maximum score is 144.

3.7 Data collection procedure

Initially an information letter was given to the parents of the children to inform them on the aims of the study and the material that is used. Informed consent of the parents and assent of the children was taken. All participants were assessed individually, in a quiet room in their school or day care setting during their attendance there.

Three assessment sessions, each 30 – 45 minutes long took place for each child. There were short breaks between tasks to give children the chance of free play or physical activities. Task order and material were organised so as to eliminate practice effects on performance and ensure that children would be interested in the procedure and motivated to complete the assessment. The order of the tasks per session can be seen in Table 3-11.

Table 3-11 Order of tasks in each Session

Session 1	Session 2	Session 3
1. Audiometric test 2. DDK task 3. D.V.I.Q. production 3.1. Block A included in DVIQ 3.2. Block C included in comprehension 4. RW Aud D (phonological) 4.1. Practice block 4.2. Block A 4.3. Block B 5. D.V.I.Q. production 5.1. Block B experimental from comprehension 5.2. Block D experimental from production 6. Word finding 7. NW Aud D phonological 7.1. Block A 7.2. Block B 8. NW Aud D morphological 8.1. Block A 8.2. Block B	1. DVIQ comprehension 1.1. Block A included in DVIQ 1.2. Block C included in production 2. Bus story 3. DVIQ comprehension 3.1. Block B experimental from comprehension 3.2. Block D experimental from the production 4. RWAudD picture choice (phonological) 4.1. Block A 4.2. Block B 5. RW AudD (morphological) 5.1. Block A 5.2. Block B 6. STM	1. NW Rep (morphological) 1.1. Block A 1.2. Block B 2. NW Rep (phonological) 2.1. Block A 2.2. Block B 2.3. Block C 3. Mispronunciation Judgment (polysyllabic) 3.1. Practice block 3.2. Block A 3.3. Block B 4. Sentence repetition D.V.I.Q. 5. RW Rep (phonological) 5.1. Block A 5.2. Block B 5.3. Block C 6. Syllable Blending 7. RW Rep (morphological) 7.1. Block A 7.2. Block B 7.3. Action picture 8. Syllable Segmentation

The tasks were administered by the author. Before the administration of each task the participating child was given a description of the material and instructions for the procedure. For the input tasks of Real Word auditory discrimination, RW Auditory discrimination with picture choice and mispronunciation detection there was a practice block to ensure that the child had adequately understood the procedure. For the STM task and PA tasks there were two practice items used before the administration of task items.

The input stimuli had been recorded by a female native Greek speaker in a quiet room using Audacity 3.1. Beta set at 22050 Hz with a USB microphone. The pictures used in experimental tasks were clip art pictures. The tasks had been administered to a small group of 5 pre- school aged children at a piloting stage to ensure that the clipart pictures were appropriate. Self corrections were accepted in language production tasks and the final answer was scored. In real and nonword repetition tasks if there was more than one production of the target stimulus it was the first attempt that was scored. Children's responses were recorded in an 'olympus' digital voice recorder. At the beginning of the session the recorder was placed on the desk used by the researcher and the child, at a minimum of twenty centimetres from the child. The children knew from the first meeting in which they gave their assent, that the procedure is to look at a computer and talk and that it needs to be recorded, to enable the researcher to remember what was said. Children were praised for participation and not for the accuracy of their answers. At the completion of all assessment tasks children were informed that there would be a next phase of assessment six months later to monitor their progress as they get older.

3.8 Inter rater reliability

Scoring of performance in input tasks was done online by the computer or by the experimenter at the time of testing based on the participant's choice. In order to ensure the reliability of scoring performance in output tasks, in addition to the researcher who scored all items, a Greek-speaking qualified SLT scored approximately 10% of the total number of recordings from data collected from eight children at T1 for the tasks of real word and nonword repetition, naming, segmentation and DVIQP. The amount of data given to the second rater can be seen in Appendix 5. An inter-rater reliability analysis using the Kappa statistic was performed to determine consistency between the experimenter and the second SLT. Inter-rater agreement was found to be above the level of chance ($p<.001$) on real word repetition, nonword repetition, polysyllabic words, polysyllabic nonwords, naming, scored both for whole word accuracy and percentage of consonants correct, segmentation and DVIQP.

Chapter 4. Development of language, speech processing, phonological awareness and short term memory skills: results of the normative study.

This chapter will present the results for the normative study. Data was collected on a wide range of language, speech processing, phonological awareness and short term memory skills from two groups of typically developing Greek children. Participating children were assessed during pre – school age, i.e. before the commencement of formal literacy instruction on 1st grade. Participants in Group 1 were children aged 3; 0 - 3; 6 and participants in Group 2 were children aged 4; 6 – 5; 0 at the beginning of the study. The children were assessed on the same battery of tests, using material and procedures as described in Chapter 3. Data was collected longitudinally at 3 time points, 6 months apart.

This chapter presents the performance of children in the various assessment tasks at each time point. The aim is to describe the development of language skills, speech processing skills, phonological awareness, and memory during the preschool period. This investigation is of particular importance for describing the development of spoken language skills in Greek, as there are few data available for Greek speaking children in the age range from 3; 0 to 6; 0 years, when written language is not officially taught. Statistical analysis is performed to establish whether the tasks used are developmentally sensitive.

Comparison of performance on different tasks at the same time point and investigation of the correlations of performance on different tasks is the objective in Chapter Five. In the current chapter the performance of children in the range of tasks is compared to the performance of the same children on the same tasks at different time points. Data was collected in three time points for Group 1 and three time points for Group 2. Comparisons of performance will be made for all tasks across the different time points, which will be presented as continuous for each group as can be seen in Figure 4-1.

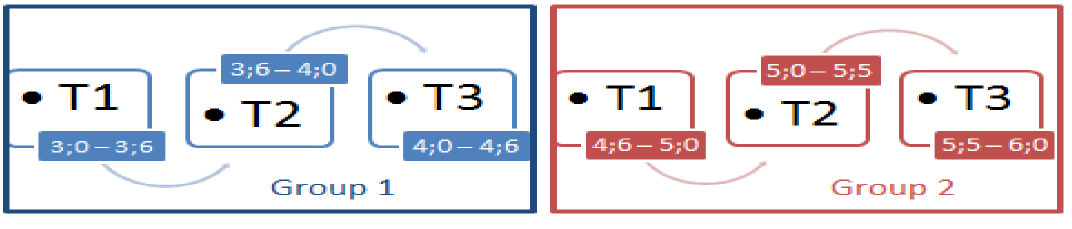

Figure 4-1 Schematic representation of the time points and the age of the children in each group during data collection used for comparison of assessment performance in each task

The current chapter seeks to investigate the typical course of development of language, speech processing, phonological awareness and STM skills in Greek speaking children. The analysis of the data over time investigates whether the experimental tasks are developmentally sensitive. In particular, it seeks to provide a description of the development of speech processing skills in typically developing Greek speaking children aged 3.0 to 6.0 years, for which previously there were little or no available data. From a theoretical view point analysis may inform theories of speech and language development, with regard to the developmental progression of speech processing skills and critical periods for the developent of certain skills. In the context of the present thesis, analysis of the longitudinal study data is also used as a reference for the intervention case studies in Chapter 6, as a baseline assessment of children with speech and/ or language difficulties. More widely, it may be useful as reference data for speech and language therapists working with Greek-speaking children in their clinical practice.

Data will be presented in the following order

- Development of language skills over time
- Development of speech processing over time. Performance on different tasks will be presented using the psycholinguistic profile questions.
- Development of phonological awareness over time.
- Development of short term memory over time

It is hypothesised that there will be significant differences in performance between testing points within each age group on the following:

1. Language measures
2. Speech processing
3. Phonological awareness
4. Short term memory

4.1 Development of language skills over time

A number of published and experimental assessment tasks were used to assess the development of language skills, in particular language comprehension and production of morphosyntax, vocabulary knowledge, elicited language production and spontaneous language production in narratives. Analysis of the data will indicate whether the language skills measured by the selected tests develop with age.

It is hypothesized that there will be significant differences in within each age group between testing points on:

- language comprehension performance
- language production performance
- sentence repetition performance
- vocabulary assessment performance
- elicited language assessment performance
- spontaneous language production assessment

4.1.1 Diagnostic Test of Verbal Intelligence (DVIQ)

In order to assess the development of language skills the Diagnostic Test of Verbal Intelligence (DVIQ, Stavrakaki & Tsimpli, 2000) was used, specifically the subtests of language comprehension (DVIQ C), production of grammar and syntax (DVIQ P) and sentence repetition (DVIQ SR) (as presented in section 3.3.1). Experimental stimuli were used in supplementary blocks to assess certain phenomena of interest both in language comprehension (DVIQCExp) and production (DVIQPExp) (as presented in section 3.5.1). This section presents the results of published language assessment tasks and supplementary blocks of experimental stimuli for the two groups of typically developing children. The objective is twofold: firstly to describe the language skills of very young children, for whom data are not available, secondly to ensure that the tasks used are sensitive to detect developmental changes.

Means, standard deviations and ranges were calculated for number of items correct for each age group at each assessment point for DVIQ C (see Table 4-1), DVIQ P (see Table 4-2) and DVIQ SR (see Table 4-3) and for supplementary experimental tasks DVIQCExp (see Table 4-4) and DVIQPExp (see Table 4-5).

Table 4-1 Descriptive Statistics for each age group on DVIQ Comprehension

Group		Age	Total	Mean	Std. Deviation	Minimum Score	Maximum Score	Kolmogorov - Smirnov
1	T1	3;0 – 3;6	31	14.88	3.05	11	22	p= .757
	T2	3;6 – 4;0	31	18.88	3.34	14	25	p= .772
	T3	4;0 – 4;6	31	21.00	3.63	15	26	p= .627
2	T1	4;6 – 5;0	31	19.54	4.98	9	27	p= .795
	T2	5;0 – 5;6	31	24.84	2.91	21	31	p= .808
	T3	5;6 – 6;0	31	26.00	2.16	22	30	p= .604

Table 4-2 Descriptive Statistics for each age group on DVIQ Production

Group		Age	Total	Mean	Std. Deviation	Minimum Score	Maximum Score	Kolmogorov - Smirnov
1	T1	3;0 – 3;6	24	8.13	3.82	2	16	p= .691
	T2	3;6 – 4;0	24	10.81	4.27	4	17	p= .663
	T3	4;0 – 4;6	24	15.06	3.82	9	20	p= .684
2	T1	4;6 – 5;0	24	11.27	3.12	5	16	p= .869
	T2	5;0 – 5;6	24	15.94	4.17	6	22	p=685 .
	T3	5;6 – 6;0	24	16.11	2.33	12	19	p= .713

Table 4-3 Descriptive Statistics for each age group on DVIQ Sentence Repetition

Group		Age	Total	Mean	Std. Deviation	Minimum Score	Maximum Score	Kolmogorov - Smirnov
1	T1	3;0 – 3;6	48	29.25	12.51	9	47	p= .940
	T2	3;6 – 4;0	48	42.50	4.79	32	47	p= .720
	T3	4;0 – 4;6	48	45.73	2.34	39	48	p= .400
2	T1	4;6 – 5;0	48	43.20	5.42	25	48	p= .328
	T2	5;0 – 5;6	48	45.94	2.77	37	48	p= .336
	T3	5;6 – 6;0	48	45.22	5.11	28	48	p= .074

Table 4-4 Descriptive Statistics for each age group on DVIQ Comprehension Experimental

Group		Age	Total	Mean	Std. Deviation	Minimum Score	Maximum Score	Kolmogorov - Smirnov
1	T1	3;0 – 3;6	23	12.27	2.37	9	18	p= .406
	T2	3;6 – 4;0	23	16.19	3.27	11	21	p= .854
	T3	4;0 – 4;6	23	18.25	2.29	13	22	p= .994
2	T1	4;6 – 5;0	23	15.36	5.22	7	23	p= .905
	T2	5;0 – 5;6	23	20.42	2.34	14	23	p= .526
	T3	5;6 – 6;0	23	20.72	1.99	15	23	p= .080

Table 4-5 Descriptive Statistics for each age group on DVIQ Production Experimental

Group		Age	Total	Mean	Std. Deviation	Minimum Score	Maximum Score	Kolmogorov - Smirnov
1	T1	3;0 – 3;6	26	8.19	4.15	0	15	p= .939
	T2	3;6 – 4;0	26	13.25	3.51	7	20	p= .955
	T3	4;0 – 4;6	26	16.19	3.54	11	22	p= .767
2	T1	4;6 – 5;0	26	14.50	3.32	9	21	p= .871
	T2	5;0 – 5;6	26	19.31	3.79	12	26	p= .816
	T3	5;6 – 6;0	26	20.16	2.65	15	26	p= .980

Kolmogorov – Smirnov and visual inspection of the histograms reveal that data were normally distributed, so Repeated Measures Anova was used to compare performance.

For Group 1 there was a main effect of time on all language subtests, i.e. DVIQ C ($F_{(2,14)}$ = 19.46, p<.001). DVIQ P ($F_{(2,14)}$ = 68.86, p<.001), DVIQ SR ($F_{(2, 14)}$ = 13.16, p=.001) as well as on experimental subtests i.e. DVIQCExp ($F_{(2,13)}$=54.18, p<.001) and DVIQPExp ($F_{(2,14)}$=18.89, p<.001). Pairwise comparisons (with Bonferroni adjustment for multiple comparisons) yielded for DVIQ C a significant difference between T1 and T2 (p=.002) and between T1 and T3 (p<.001). Significant difference was found between all time points for DVIQ P between T1 and T2 (p=.018), between T2 and T3 (p<.001), between T1 and T3 (p<.001). Significant difference was also found between all time points on DVIQ SR between T1 and T2 (p=.001), between T2 and T3 (p=.015) and between T1 and T3 (p=.001). For both experimental tasks significant difference was found between all time points. For DVIQCExp significant difference was found between T1 and T2 (p<.001), between T2 and T3 (p=.007) and between T1 and T3 (p<.001). For DVIQPExp significant difference was found between T1 and T2 (p=.008), between T2 and T3 (p=.01) and between T1 and T3 (p<.001).

For Group 2 there was a main effect of time on all language subtests, i.e. DVIQ C ($F_{(2,17)}$ = 12.46, p<.001), DVIQ P ($F_{(2,17)}$ = 20.70, p<.001) and DVIQ SR ($F_{(2,12)}$ = 5.16, p=.024) as well as on experimental subtests i.e. DVIQCExp ($F_{(2,16)}$ =8.9, p=.003) and DVIQPExp ($F_{(2,17)}$ =18.89, p<.001). Pairwise comparisons (with Bonferroni adjustment for multiple comparisons) yielded for DVIQ C a significant difference between T1 and T2 (p=.002) and between T1 and T3 (p<.001). For DVIQ P significant difference was found between T1 and T2 (p=.001) and between T1 and T3 (p<.001). For DVIQ SR significant difference was only found between T1 and T2 (p=.022). Inspection of the means indicates that children approached ceiling (total score 48) from the first assessment. For experimental tasks significant difference was found for DVIQCExp between T1 and T2 (p=.004) and between T1 and T3 (p=.002). For DVIQPExp significant difference was found between T1 and T2 (p<.001) and between T1 and T3 (p<.001).Performance of the two groups across time points for DVIQ C is presented in Figure 4-2, for DVIQ P is presented in Figure 4-3, for DVIQ SR is presented in Figure 4-4, for DVIQCExp is presented in Figure 4-5 and for DVIQPExp is presented in Figure 4-6 .

Statistically significant differences are indicated with an asterisk. In the case of statistically significant differences between two consecutive time points the asterisk is marked above the line, between the two points of time where the difference is observed. In the case of statistically significant differences between the first and the third time point, the asterisk is marked below the line in the middle. This coding applies to all subsequent figures.

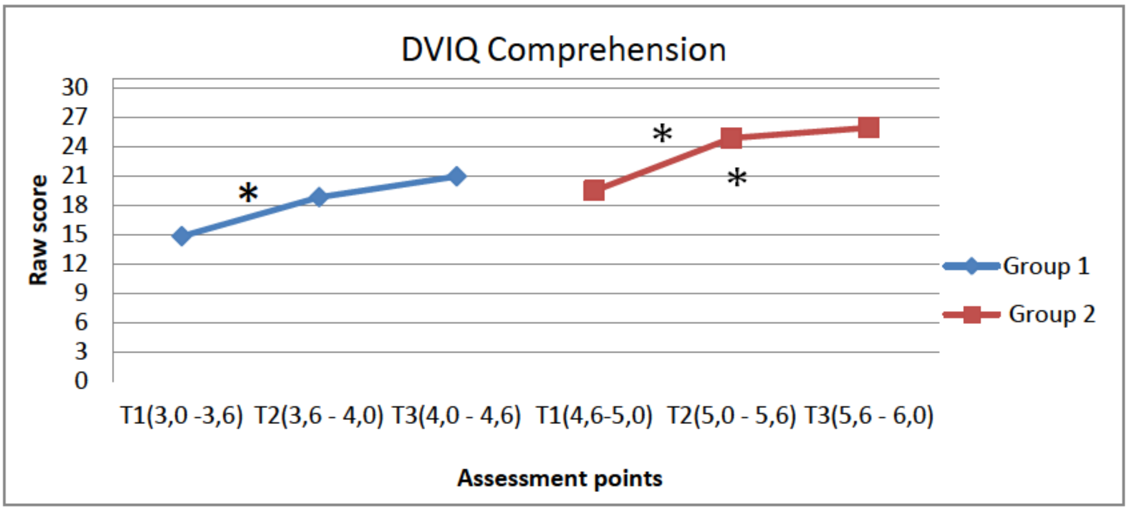

Figure 4-2 Performance on DVIQ Comprehension across time points

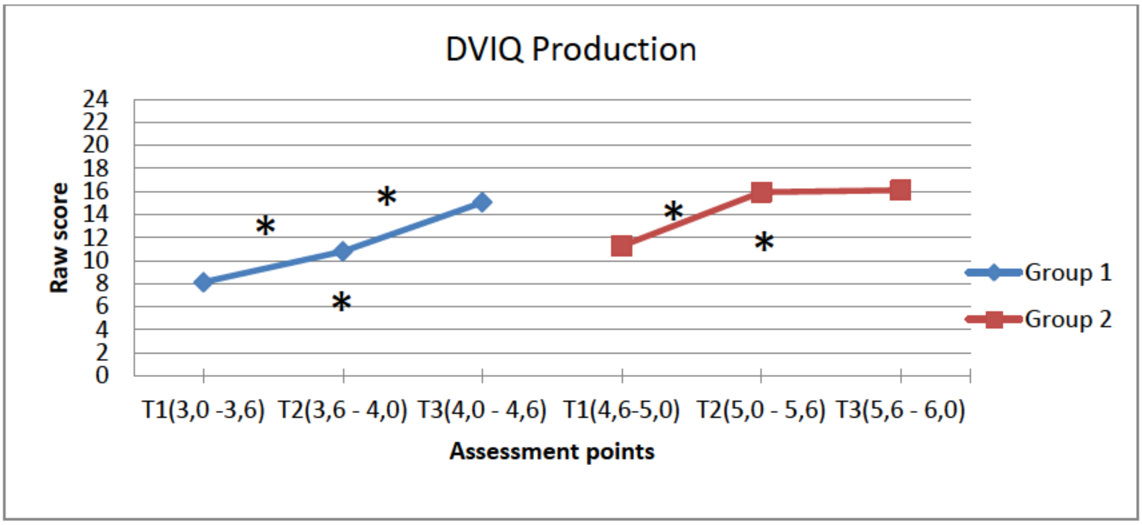

Figure 4-3 Performance on DVIQ Production across time points

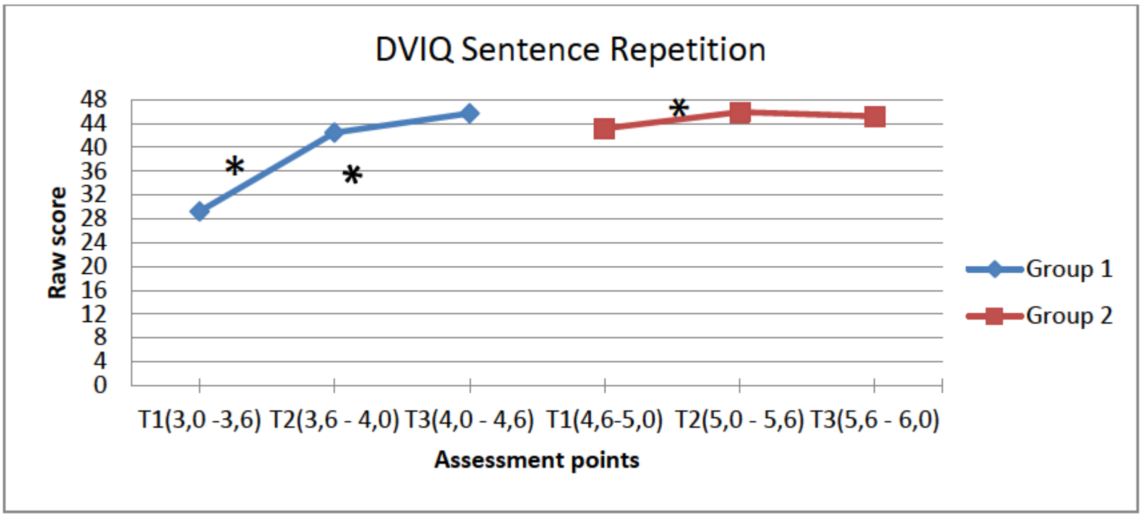

Figure 4-4 Performance on DVIQ Sentence Repetition across time points

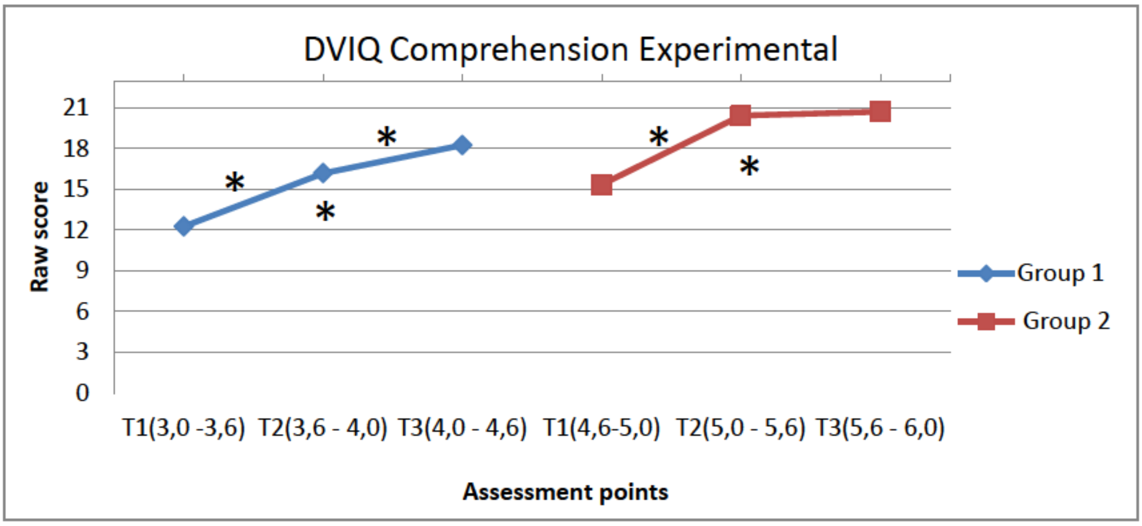

Figure 4-5 Performance on DVIQ Comprehension Experimental

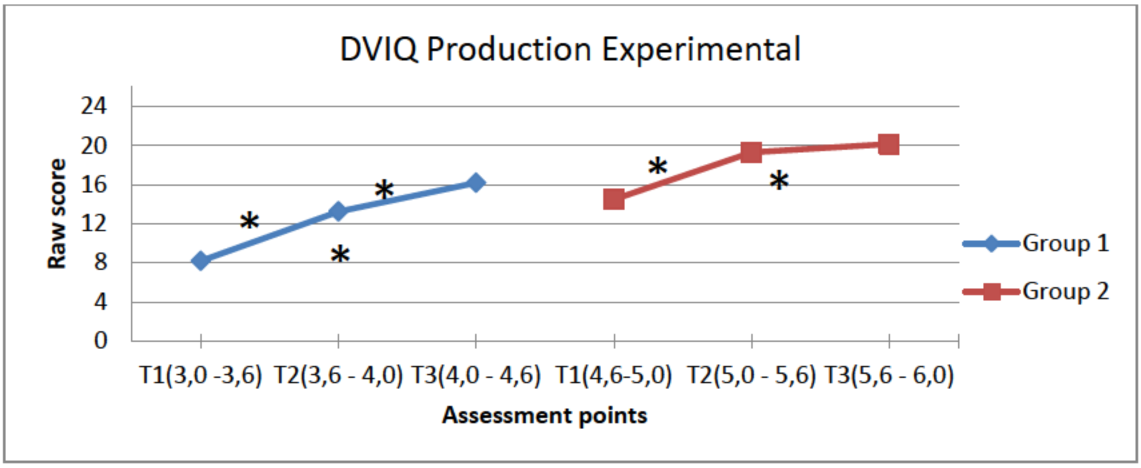

Figure 4-6 Performance on DVIQ Production Experimental

For Group 1 significant differences were found for all tasks across time points, with the exception of DVIQ C between T2 and T3. For Group 2 significant difference in performance was observed between T1 and T2 as well as between T1 and T3.

DVIQ is sensitive in identifying developmental changes, even in children of a younger age than those to whom the test was standardized.

Experimental stimuli are also sensitive in identifying developmental change, both in comprehension and production of certain phenomena of interest. Input and output speech processing performance for these experimental stimuli is presented in section 4.2.

4.1.2 Vocabulary (Renfrew word finding test)

In order to assess productive vocabulary children were asked to complete the Greek adaptation of the Renfrew test of word finding (Vogindroukas, Protopapas, & Sideris, 2009 (see section 3.3.2.i). Means, standard deviations and range were calculated for number of items correct for each age group at each assessment point (see Table 4-6).

Table 4-6 Descriptive Statistics for each age group on Renfrew Word Finding Test

Group		Age	Total	Mean	Std. Deviation	Minimum Score	Maximum Score	Kolmogorov - Smirnov
1	T1	3;0 – 3;6	50	13.38	6.89	5	29	p= .230
	T2	3;6 – 4;0	50	16.44	6.51	7	32	p= .855
	T3	4;0 – 4;6	50	22.25	7.92	11	40	p= .626
2	T1	4;6 – 5;0	50	23.23	8.02	9	35	p= .994
	T2	5;0 – 5;6	50	29.21	6.84	18	40	p= .791
	T3	5;6 – 6;0	50	33.68	5.51	22	43	p= .996

Kolmogorov Smirnov and visual inspection of the histograms reveal that data were normally distributed, so Repeated Measures Anova was used to compare performance.

For Group 1 there was a main effect of time ($F_{(2,\ 14)}$ = 43.35, p<.001). Pairwise comparisons (with Bonferroni adjustment for multiple comparisons) yielded highly significant difference in vocabulary production between all time points i.e. between T1 and T2 (p=.010), between T2 and T3 (p<.001) and between T1 and T3 (p<.001).

For Group 2 there was a main effect of time ($F_{(2,\ 17)}$ = 40.47, p<.001). Pairwise comparisons (with Bonferroni adjustment for multiple comparisons) yielded highly significant difference in vocabulary production between all time points i.e. between T1 and T2 (p=.001), between T2 and T3 (p<.001) and between T1 and T3 (p<.001).

Performance of the two groups across time points is presented in Figure 4-7.

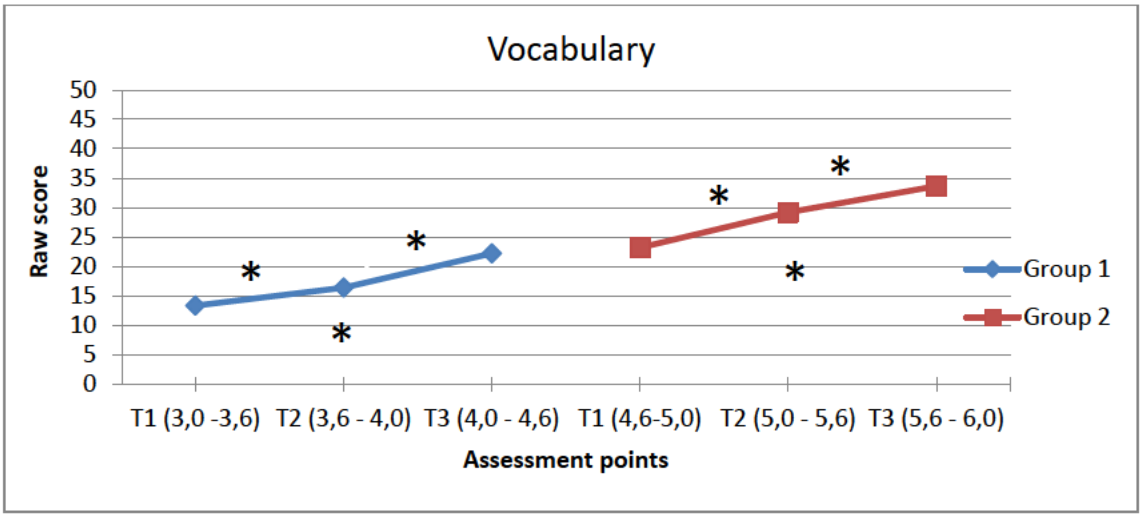

Figure 4-7 Performance on Renfrew Word Finding Task across time points

The Greek version of the RWFT appears to be sensitive to developmental changes in vocabulary across time in children aged 3; 0 – 6; 0.

4.1.3 Elicited language production

In order to assess elicited language production children were asked to complete the Greek version of the Renfrew Action Picture Test (RAPT)(Vogindroukas, Stavrakaki, & Protopapas, 2011) (see section 3.3.2.ii). Means, standard deviations and ranges were calculated for grammatical elements accurately produced (RAPT Grammar) (see Table 4-7) and for information provided (RAPT Information) (see Table 4-8).

Table 4-7 Descriptive statistics for each age group for Renfrew Action Picture test, Grammar Score

Group		Age	Total	Mean	Std. Deviation	Minimum Score	Maximum Score	Kolmogorov - Smirnov
1	T1	3;0 – 3;6	66	18.13	8.66	4	32	p= .604
	T2	3;6 – 4;0	66	25.43	8.63	8	37	p= .854
	T3	4;0 – 4;6	66	38.73	9.17	14	48	p= .781
2	T1	4;6 – 5;0	66	32.35	12.41	16	56	p= .763
	T2	5;0 – 5;6	66	44.79	7.36	30	58	p= .838
	T3	5;6 – 6;0	66	47.33	5.37	36	55	p= .743

Table 4-8 Descriptive statistics for each age group for Renfrew Action Picture test, Information Score

Group		Age	Total	Mean	Std. Deviation	Minimum Score	Maximum Score	Kolmogorov - Smirnov
1	T1	3;0 – 3;6	50	14.20	6.75	4	28	p= .872
	T2	3;6 – 4;0	50	17.68	6.50	8	27	p= .580
	T3	4;0 – 4;6	50	25.21	4.97	16	35	p= .930
2	T1	4;6 – 5;0	50	24.65	5.31	15	37	p= .892
	T2	5;0 – 5;6	50	29.00	6.12	19	42	p= .707
	T3	5;6 – 6;0	50	33.22	6.11	23	45	p= .894

Kolmogorov Smirnov and visual inspection of the histograms reveal that data were normally distributed, so Repeated Measures Anova was used to compare performance.

For Group 1 there was a main effect of time both for RAPT Grammar ($F_{(2, 11)}$ =21.06, p<.001) and RAPT Information ($F_{(2, 11)}$ = 17.37, p<.001). Pairwise comparisons (with Bonferroni adjustment for multiple comparisons) yielded highly significant difference in performance across time points for RAPT Grammar score i.e. between T1 and T2 (p=.029), between T1 and T3 (p<.001) and between T2 and T3 (p=.001). However, for RAPT Information Score a significant difference was found only between T1 and T3 (p<.001)

For Group 2 there was a main effect of time both for RAPT Grammar ($F_{(2, 14)}$ =10, 81, p<.001) and RAPT Information ($F_{(2, 14)}$ =21.45, p<.001). Pairwise comparisons (with Bonferroni adjustment for multiple comparisons) yielded for RAPT Grammar significant differences between T1 and T2 (p=.003) and between T1 and T3 (p=.001). For RAPT Information significant differences were found across time points i.e. between T1 and T2 (p=.009), between T1 and T3 (p<.001) and between T2 and T3 (p=.039).

Performance of the two groups across time points for RAPT Grammar is presented in Figure 4-8 and for RAPT Information is presented in Figure 4-9.

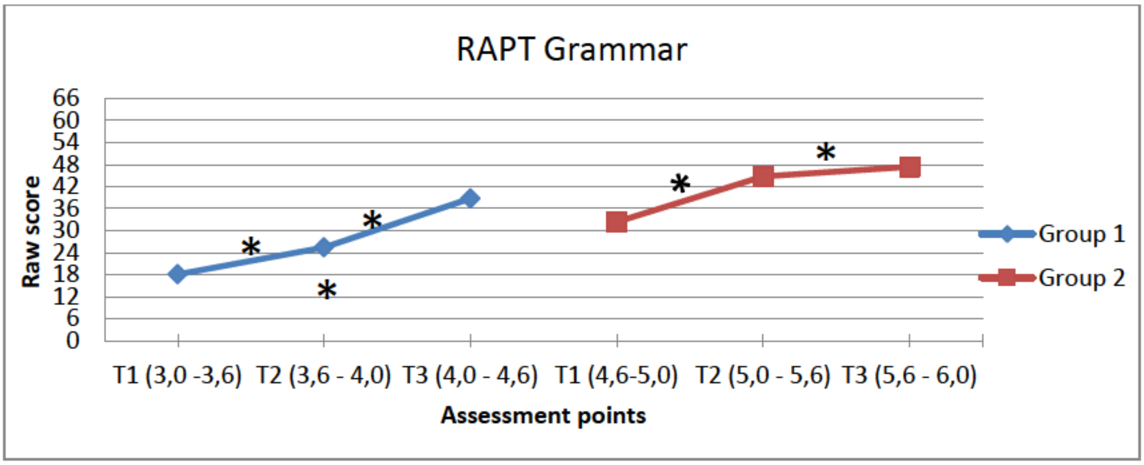

Figure 4-8 Performance on Renfrew Action Picture Test Grammar score across time points

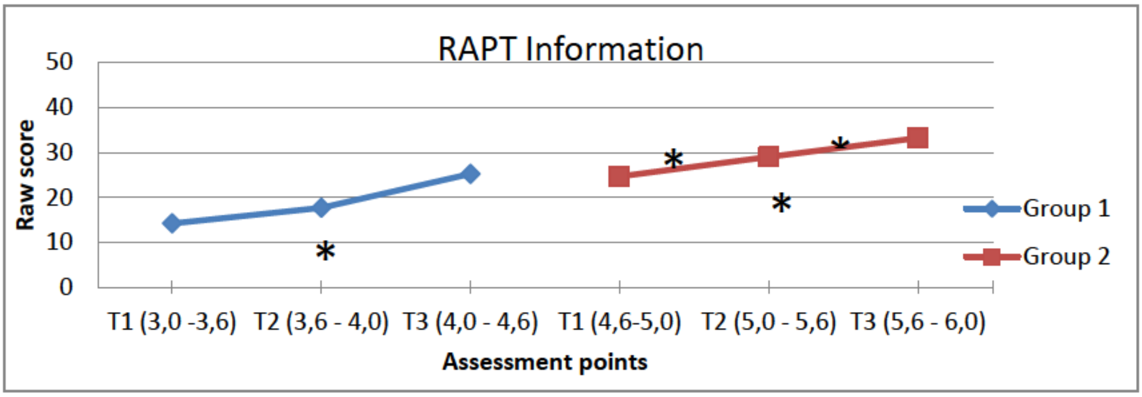

Figure 4-9 Performance on Renfrew Action Picture Test Information score across time points

RAPT is sensitive in identifying developmental changes in elicited production of grammar in children aged 3; 0 – 6; 0. For information score in group 1 statistically significant difference was only observed over the course of a year. Given that norms in the published assessment (Vogindroukas, Stavrakaki, & Protopapas, 2011) are provided per year for children aged 4 – 7 years, a direct comparison of performance is not possible, especially for Group 1 in the first two points of data collection.

4.1.4 Language production in spontaneous speech sample

In order to assess spontaneous language production children were assessed with a Greek adaptation of Renfrew Bus story test (Sgourdou, 2005) (see section 3.3.2.iii). Means, standard deviations and ranges were calculated for the Score of Information provided (Bus Inf) (Table 4-9), Mean Length of Utterance of the five longest sentences (Bus MLU) (Table 4-10) and the Number of Subordinate clauses included in the sample (Bus Sub)(Table 4-11).

Table 4-9 Descriptive statistics for each age group on Bus Story test Information Score

Group		Age	Mean	Std. Deviation	Minimum Score	Maximum Score	Kolmogorov - Smirnov
1	T1	3;0 – 3;6	7.87	6.18	2	22	p= .512
	T2	3;6 – 4;0	9.56	5.79	3	22	p= .580
	T3	4;0 – 4;6	13.00	5.06	5	24	p= .440
2	T1	4;6 – 5;0	13.81	7.89	0	28	p= .960
	T2	5;0 – 5;6	20.15	7.30	8	34	p= .707
	T3	5;6 – 6;0	26.11	7.68	13	44	p= .973

Table 4-10 Descriptive statistics for each age group on Bus Story test Mean Length of Utterance

Group		Age	Mean	Std. Deviation	Minimum Score	Maximum Score	Kolmogorov - Smirnov
1	T1	3;0 – 3;6	6.99	2.10	3.20	10.80	p= 1.0
	T2	3;6 – 4;0	7.63	1.68	4.00	11.20	p= .803
	T3	4;0 – 4;6	10.52	3.06	5.00	17.80	p= .826
2	T1	4;6 – 5;0	9.99	4.28	0	16	p= .602
	T2	5;0 – 5;6	12.10	3.34	6.40	19.20	p= .825
	T3	5;6 – 6;0	13.47	2.66	8.60	17.80	p= .997

Table 4-11 Descriptive statistics for each age group on Bus Story test production of Subordinate Clauses

Group		Age	Mean	Std. Deviation	Minimum Score	Maximum Score	Kolmogorov - Smirnov
1	T1	3;0 – 3;6	0.13	0.35	0	1	p= .001
	T2	3;6 – 4;0	1.37	2.0	0	8	p= .222
	T3	4;0 – 4;6	2.47	1.96	0	6	p= .624
2	T1	4;6 – 5;0	3.0	2.49	0	8	p= .636
	T2	5;0 – 5;6	4.58	3.04	1	11	p= .294
	T3	5;6 – 6;0	5.11	2.63	1	10	p= .353

Kolmogorov Smirnov and visual inspection of the histograms reveal that data were normally distributed, so Repeated Measures Anova was used to compare performance.

For Group 1 there was a main effect of time on all three measurements i.e. Bus Inf ($F_{(2, 12)}$ =20.51, P<.001), Bus MLU ($F_{(2, 12)}$ =12.03, p=.002) and Bus Sub ($F_{(2, 12)}$ =11.59, p=.002). Pairwise comparisons (with Bonferroni adjustment for multiple comparisons) yielded for Bus Inf significant difference in performance between T1 and T2 (p<.001) and between T1 and T3 (p=.001), for Bus MLU significant difference in performance between T1 and T3 (p=.001) and between T2 and T3 (p=.005) and significant difference in Bus Sub between T1 and T3 (p=.001).

For Group 2 there was a main effect of time on all three measurements i.e. Bus Inf ($F_{(2, 16)}$ =30.25, p<.001), Bus MLU ($F_{(2,16)}$ =3.74, p=.046) and Bus Sub ($F_{(2,16)}$ =4.88, p<.022). Pairwise comparisons (with Bonferroni adjustment for multiple comparisons) yielded significant difference in Bus Inf between T1 and T2 (p<.014), between T2 and T3 (p=.001) and between T1 and T3 (p<.001). Significant difference was found only between T1 and T3 for Bus MLU (p=.035) and Subordinate clauses (p=.015).

The most apparent differences across time for both groups are observed in Bus Inf. The Mean Length of Utterance and subordinate clauses appear to be more slowly developing; therefore significant differences are only evident between T1 and T3. Subordinate clauses are not used early on by young children as a group, as can be seen by floor effect performance at T1.

Performance of the two groups across time points on Bus Inf is presented in Figure 4-10, Bus MLU is presented in Figure 4-11 and Bus Sub is presented in Figure 4-12.

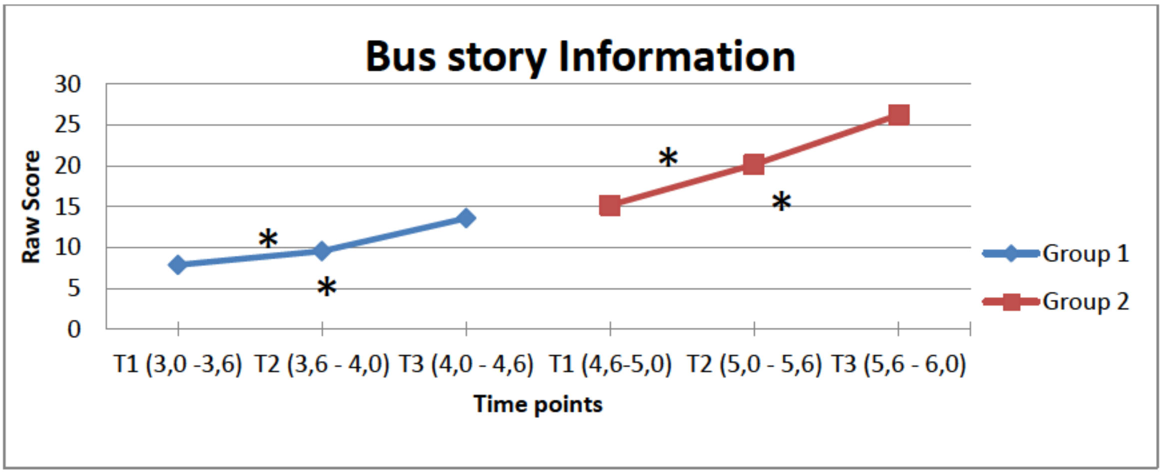

Figure 4-10 Performance on Renfrew Bus Story Information score across time points

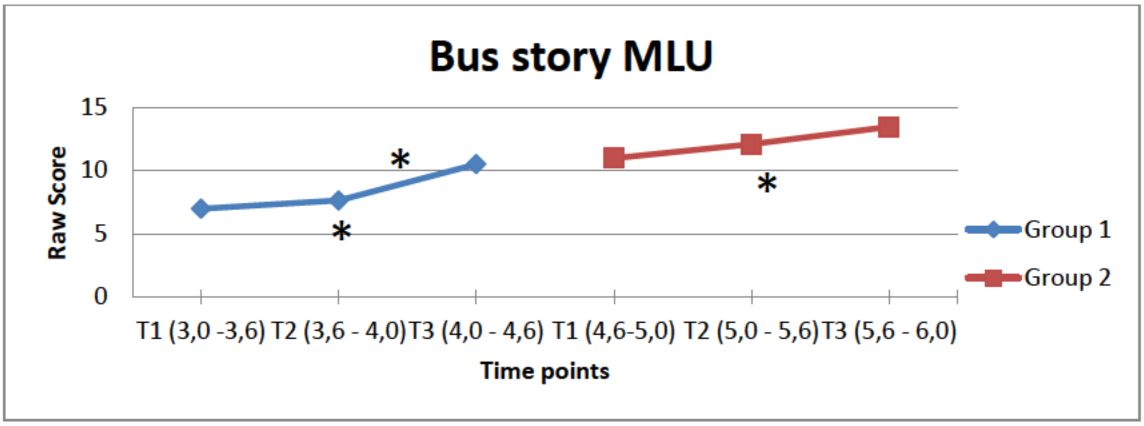

Figure 4-11 Performance on Renfrew Bus Story Mean Length of Utterance across time points

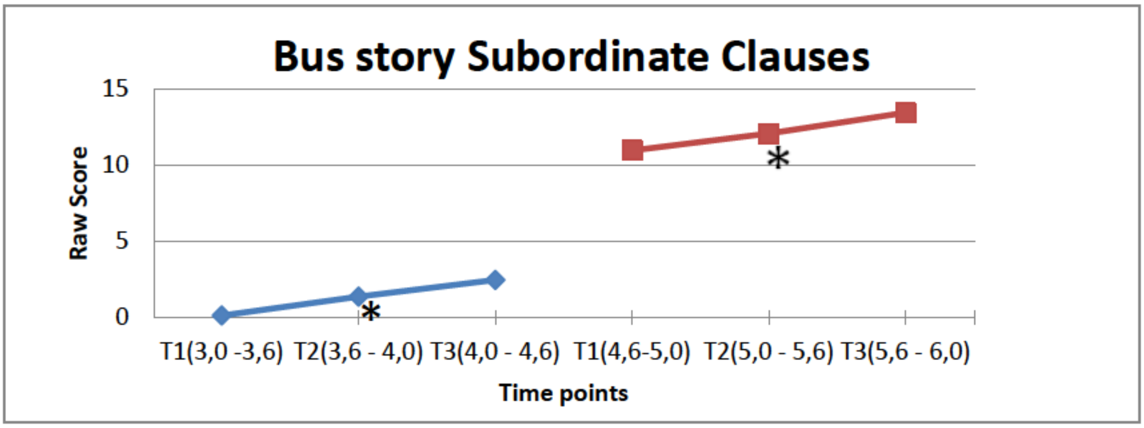

Figure 4-12 Performance on Renfrew Bus story production of Subordinate Clauses across time points

The Greek adaptation of Bus Story test is not a published assessment, but is based on a pilot study. It is possible that as it is not fully standardized the test is not sensitive enough to detect changes over the course of six months. Another possible reason is that narrative discourse is a complex process and developmental rate is slow, so that statistically significant changes do not occur within six months.

4.1.5 Summary

Significant differences in performance between testing points within each age group were found in language comprehension, language production (elicited and spontaneous), repetition of syntactic structures and vocabulary production. Language skills are significantly developing in the preschool years. Supplementary blocks using experimental stimuli were sensitive in detecting developmental change in language comprehension and production for certain phenomena of interest. These stimuli were further used in tasks assessing speech input and output processing skills. Performance on speech processing assessment tasks is presented in section 4.2.

4.2 Development of speech processing skills over time

This section presents performance on speech processing assessment tasks i.e. processing of speech input and speech output including stored lexical representations. The questions from the psycholinguistic profile of Stackhouse & Wells (1997) (presented in chapter 2) are used as a basis to present the development of speech processing skills.

The aim of the current section is twofold: firstly, to evaluate whether the experimental tasks are developmentally sensitive; secondly, to investigate the developmental progression of speech processing skills in typically developing Greek speaking children.

It is hypothesized that there will be significant difference in speech processing skills assessment performance within each age group between testing points in:

- auditory discrimination of nonwords
- auditory discrimination of real words
- auditory tasks targeting accuracy of phonological representations
- picture naming
- real word repetition
- non-word repetition

4.2.1 Is there a difference in performance for children of different ages in discrimination between speech sounds without reference to phonological and morphological representations?

In order to assess the discrimination of speech sounds without reference to phonological and/ or morphological representation children were asked to complete four blocks of Non – word auditory discrimination. Two blocks (30 items in total) consisted of items that were based on real words with different phonological (Phon) properties (as presented in table 3.6) and two blocks (30 items in total) consisted of items that were based on real words with different morphological (Mor) properties (as presented in table 3.4). Means, standard deviations and ranges were calculated for number of items correct for each age group at each assessment point on Nonword Auditory Discrimination ABX task (NWAudD) for NWAudDPhon (Table 4-12) and NWAudDMor (Table 4-13). As there were only two possible responses for this task, there was a 50% chance of participants getting the correct answer for each item. Binomial test indicated that the chance of observing 23 or more successes in 30 trials was p=.003 (one tail). A raw score of 23/30 correct would be significantly above the chance level. Group means above chance level are marked with bold.

Table 4-12 Descriptive Statistics for each age group on Nonword Auditory Discrimination Phonological Task

Group		Age	Total	Mean	Std. Deviation	Minimum Score	Maximum Score	Kolmogorov – Smirnov
1	T1	3;0 – 3;6	30	18.56	3.98	8	24	p= .888
	T2	3;6 – 4;0	30	19.18	2.66	13	24	p= .811
	T3	4;0 – 4;6	30	**23.50**	3.27	16	28	p= .638
2	T1	4;6 – 5;0	30	22.54	3.75	15	29	p= .888
	T2	5;0 – 5;6	30	**25.84**	2.95	19	30	p= .576
	T3	5;6 – 6;0	30	**26.05**	2.75	19	30	p= .575

Table 4-13 Descriptive Statistics for each age group on Nonword Auditory Discrimination Morphological Task

Group		Age	Total	Mean	Std. Deviation	Minimum Score	Maximum Score	Kolmogorov – Smirnov
1	T1	3;0 – 3;6	30	19.81	3.45	14	24	p= .562
	T2	3;6 – 4;0	30	21.63	3.81	14	27	p= .965
	T3	4;0 – 4;6	30	**25.88**	3.07	19	30	p= .907
2	T1	4;6 – 5;0	30	**25.55**	3.75	15	30	p= .442
	T2	5;0 – 5;6	30	**27.57**	2.11	23	30	p= .642
	T3	5;6 – 6;0	30	**28.00**	2.00	22	30	p= .222

Kolmogorov Smirnov and visual inspection of the histograms reveal that data were normally distributed, so Repeated Measures Anova was used to compare performance.

For Group 1 there was a main effect of time for items of phonological ($F_{(2, 14)}$ =9.86, p= .002) and morphological ($F_{(2, 14)}$ =15.23, p<.001) interest. Pairwise comparisons (with Bonferroni adjustment for multiple comparisons) yielded a significant difference between T1 and T3 (p=.003) and between T2 and T3 (p=.008) for items of phonological interest and a significant difference between T1 and T3 (p<.001) and between T2 and T3 (p=003) for items of morphological interest.

For Group 2 there was a main effect of time for items of phonological ($F_{(2, 16)} = 15.25$, $p<.001$) and morphological ($F_{(2, 16)} = 5.07$, $p=.020$) interest. Pairwise comparisons (with Bonferroni adjustment for multiple comparisons) yielded a significant difference between T1 and T2 ($p= .005$) and between T1 and T3 ($p < .001$) for items of phonological interest and between T1 and T3 ($p= .016$) for items of morphological interest.

Performance of the two groups across time points for NWAudDPhon is presented in Figure 4-13 and for NWAudDMor is presented in Figure 4-14.

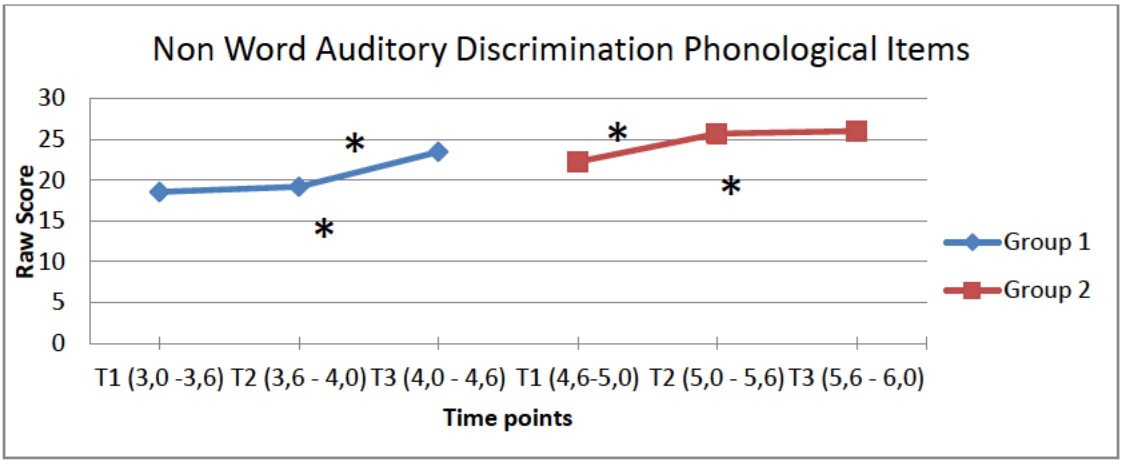

Figure 4-13 Performance on discrimination of speech sounds without reference to phonological representations across time points

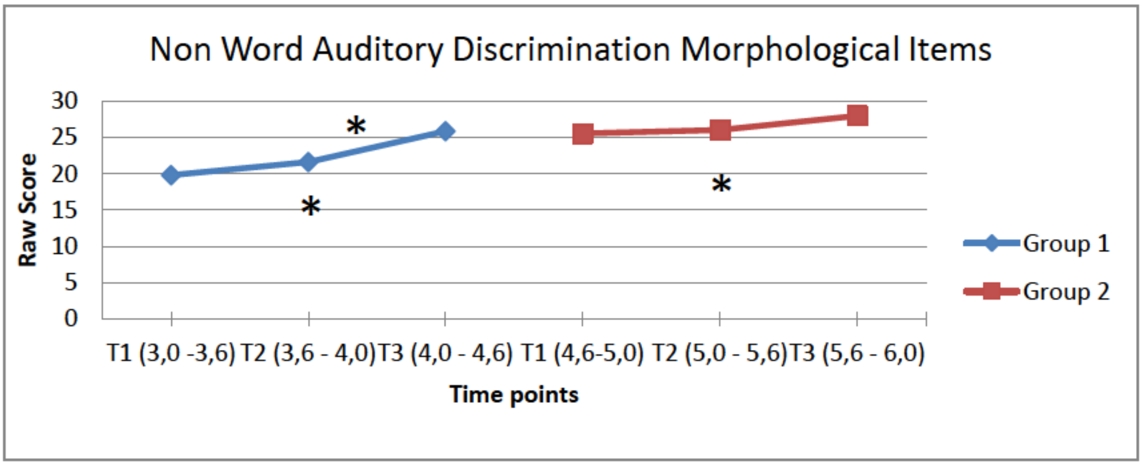

Figure 4-14 Performance on discrimination of speech sounds without reference to morphological representations across time points

For both groups there was a significant effect of time on all tasks. Auditory discrimination performance without reference to representations is a gradually developing ability. However, developmental rate can be quite slow, therefore significant differences were sometimes found only between T1 and T3. It is noteworthy that for both groups mean scores were higher and standard deviations were smaller for items of morphological than for items of phonological interest. This will be returned to in Chapter 5, where results for different tasks at the same assessment point are compared in order to investigate the role of phonological and morphological characteristics in the development of speech processing abilities.

At T1 and T2 Group 1 performed on average below chance level. This suggests either that these younger children answered randomly or that they consciously chose the option that they considered to be correct, but their skills were not yet developed sufficiently to regularly choose the correct response.

4.2.2 Is there a difference in performance for children of different ages in discrimination between real words with different phonological and morphological properties?

In order to assess the discrimination of real words that share different phonological and/ or morphological characteristics children were asked to complete four blocks of Real – Word auditory discrimination. Two blocks (30 items in total) consisted of real words with different phonological (P) properties (as presented in table 3.5) and two blocks (30 items in total) consisted of real words with different morphological (M) properties (as presented in table 3.3). Means, standard deviations and ranges were calculated for number of items correct for each age group at each assessment point on Real Word Auditory Discrimination (RWAudD) ABX task for RWAudDPhon (Table 4-14) and RWAudDMor (

Table 4-15). As there were only two possible responses for this task, there was a 50% chance of participants getting the correct answer for each item. Binomial test indicated that the chance of observing 23 or more successes in 30 trials was p=.003 (one tail). A raw score of 23/30 correct would be significantly above the chance level. Group means above chance level are marked with bold.

Table 4-14 Descriptive statistics for each age group on Real Word Auditory Discrimination Phonological Task

Group		Age	Total	Mean	Std. Deviation	Minimum Score	Maximum Score	Kolmogorov - Smirnov
1	T1	3;0 – 3;6	30	19.06	4.86	10	30	p= .593
	T2	3;6 – 4;0	30	21.81	4.15	14	27	p= .728
	T3	4;0 – 4;6	30	**24.86**	2.47	20	28	p= .550
2	T1	4;6 – 5;0	30	**23.90**	3.99	15	30	p= .753
	T2	5;0 – 5;6	30	**25.47**	1.90	21	28	p= .220
	T3	5;6 – 6;0	30	**27.39**	1.94	23	30	p= .477

Table 4-15 Descriptive statistics for each age group on Real Word Auditory Discrimination Morphological Task

Group		Age	Total	Mean	Std. Deviation	Minimum Score	Maximum Score	Kolmogorov - Smirnov
1	T1	3;0 – 3;6	30	19.18	3.70	15	27	p= .810
	T2	3;6 – 4;0	30	22.06	3.73	14	27	p= .998
	T3	4;0 – 4;6	30	**26.31**	2.91	20	30	p= .883
2	T1	4;6 – 5;0	30	**24.72**	3.99	18	30	p= .598
	T2	5;0 – 5;6	30	**26.31**	3.63	15	30	p= .157
	T3	5;6 – 6;0	30	**27.44**	2.87	22	30	p= .431

Kolmogorov Smirnov and visual inspection of the histograms reveal that data were normally distributed, so Repeated Measures Anova was used to compare performance.

For Group 1 there was a main effect of time for words with different phonological ($F_{(2,13)}$=19.11, p<.001) and morphological ($F_{(2,14)}$= 23.24, p<.001) properties. Pairwise comparisons (with Bonferroni adjustment for multiple comparisons) yielded a significant difference between T1 and T3 (p<.001) and between T2 and T3 (p<.001) for phonologically different words and a significant difference between all time points for morphologically different words (T1 vs. T2 p=.012, T2 vs. T3 p=.001).

For the Group 2 there was a main effect of time for words with different phonological ($F_{(2,16)}$=32.14, p<.001) and morphological ($F_{(2, 16)}$ = 5.68 p=.014) interest. Pairwise comparisons (with Bonferroni adjustment for multiple comparisons) yielded a significant difference between T1 and T3 (p<.001) and between T2 and T3 (p=.006) for phonologically different words and a significant difference only between T1 and T3 (p= 0,009) for morphologically different words.

Performance of the two groups across time points on RWAudDPhon is presented in Figure 4-15 and performance on RWAudDMor is presented in Figure 4-16.

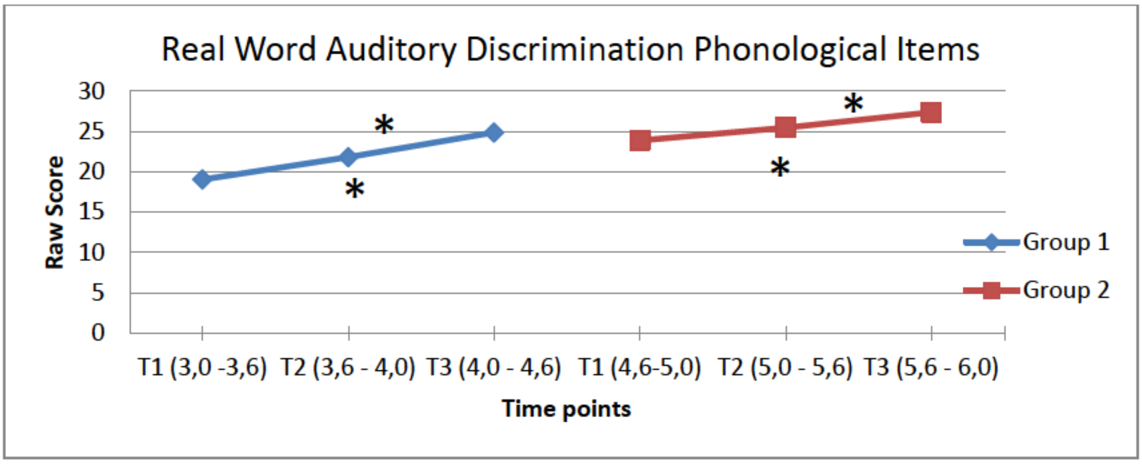

Figure 4-15 Performance on Real Word Auditory Discrimination of Phonological items across time points

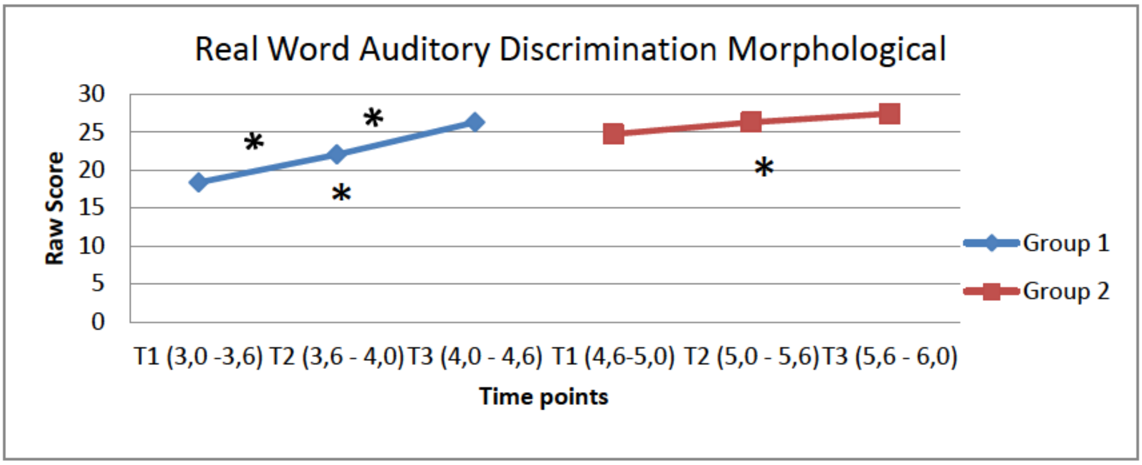

Figure 4-16 Performance on Real Word Auditory Discrimination Morphological items across time points

For both groups there was a significant effect of time on all tasks. The results indicate that auditory discrimination of words develops gradually; however, significant changes occur more in Group 1 and less in Group 2, possibly because of ceiling effects in Group 2 performance at T2 and T3. Group 1 performed below chance level at the first two assessment points and close to chance level at the third assessment point. Although this performance may be attributed to chance, it is also possible that it demonstrates a developmental progression of auditory skills related to the task. This is suggested by the finding that as children in Group 1 get older, there is a gradual increase of the means, and there is a statistically significant difference in performance from the previous assessment time, although performance is still below the level of chance.

4.2.3 Is there a difference in performance for children of different ages in accessing accurate phonological representations?

In order to assess the accuracy of underlying phonological representations children were asked to complete a Picture Choice (RWPicCh) task of the same words of standard length (as presented in Table 3.5) that were included in the Real Word Auditory Discrimination Task of Phonological interest (RWAudDPhon) and the Mispronunciation Detection Task (MisprD) for polysyllabic words (as presented in table 3.8). Both tests consisted of two blocks (30 items in total). Means, standard deviations and ranges were calculated for number of items correct for each age group at each assessment point MisprD (Table 4-16) and RWPicCh (Table 4-17).

For the Picture Choice task, there were four possible answers so the possibility of getting the correct answer for each item by chance was 25%. Binomial test was therefore carried out. The chance of observing 17 or more successes in 30 trials was p= .022. A raw score of 17/30 correct would be significantly above chance level. For the Mispronunciation detection task, there was a 50% chance of participants getting the correct answer for each item, as there were only two possible responses. Binomial test was therefore carried out. The chance of observing 23 or more successes in 30 trials was p= .003 (one tail). A raw score of 23/30 correct would be significantly above the chance level. Group means above chance level are marked with bold.

Table 4-16 Descriptive statistics for each age group on Mispronunciation Detection Task

Group		Age	Total	Mean	Std. Deviation	Minimum Score	Maximum Score	Kolmogorov – Smirnov
1	T1	3;0 – 3;6	30	20.62	4.40	12	28	p= .925
	T2	3;6 – 4;0	30	21.69	3.84	13	28	p= .421
	T3	4;0 – 4;6	30	**25.27**	2.46	21	28	p= .480
2	T1	4;6 – 5;0	30	22.57	5.18	10	28	p= .504
	T2	5;0 – 5;6	30	**25.26**	2.74	18	28	p= .441
	T3	5;6 – 6;0	30	**27.17**	1.89	23	30	p= .692

Table 4-17 Descriptive statistics for each age group on Picture choice task

Group		Age	Total	Mean	Std. Deviation	Minimum Score	Maximum Score	Kolmogorov – Smirnov
1	T1	3;0 – 3;6	30	15.31	3.60	10	23	p= .921
	T2	3;6 – 4;0	30	**19.12**	3.63	13	27	p= .536
	T3	4;0 – 4;6	30	**21.07**	3.82	14	27	p= .976
2	T1	4;6 – 5;0	30	**21.23**	3.79	10	27	p= .536
	T2	5;0 – 5;6	30	**25.36**	2.65	20	30	p= .910
	T3	5;6 – 6;0	30	**25.39**	2.54	21	29	p= .430

Kolmogorov Smirnov and visual inspection of the histograms reveal that data were normally distributed, so Repeated Measures Anova was used to compare performance.

For Group 1 there was a main effect of time on accurate picture choice ($F_{(2, 13)}$= 14.65, p<.001) and mispronunciation detection ($F_{(2, 13)}$= 16.41, p<.001). Pairwise comparisons (with Bonferroni adjustment for multiple comparisons) yielded a significant difference in performance on picture choice between T1 and T2 (p=.005), T1 and T3 (p<.001), while comparison between T2 and T3 just missed significance (p=.050). Comparison of performance for mispronunciation judgment yielded significant difference between T1 and T3 (p=.002) and between T2 and T3 (p=.005).

For Group 2 there was a main effect of time on accurate picture choice ($F_{(2, 16)}$=8.70, p=.003) and mispronunciation detection ($F_{(2, 15)}$=6.63, p=.009). Pairwise comparisons (with Bonferroni adjustment for multiple comparisons) yielded a significant difference on accurate picture choice between T1 and T2 (p=.003) and between T1 and T3 (p=.003) whereas accuracy of mispronunciation judgment significantly improved only between T1 and T3 (p=.006).

Performance of the two groups across time points for RWPicCh is presented in Figure 4-17 and for MisprD is presented in Figure 4-18.

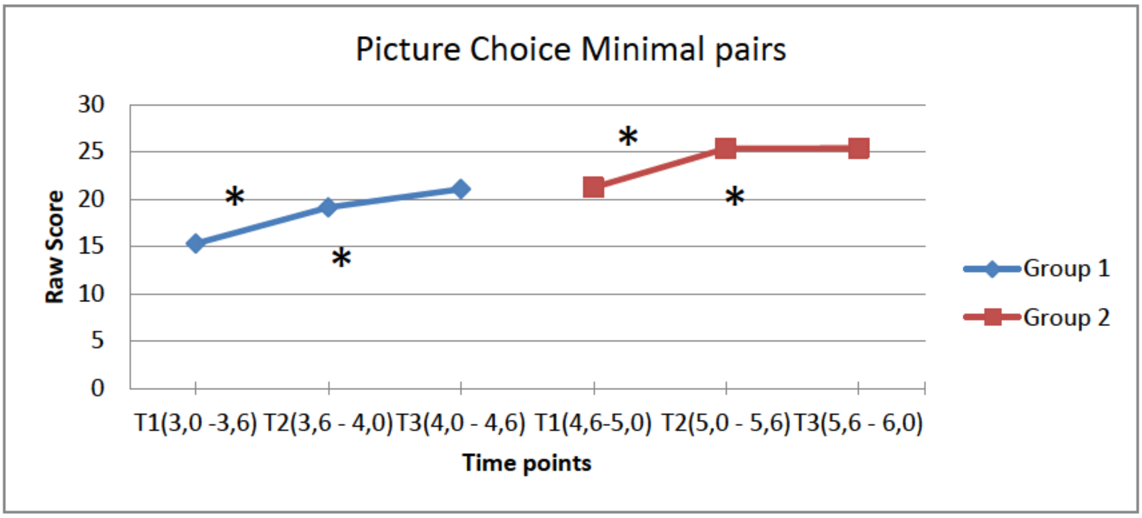

Figure 4-17 Performance on Picture Choice of Phonological Minimal pairs across time points

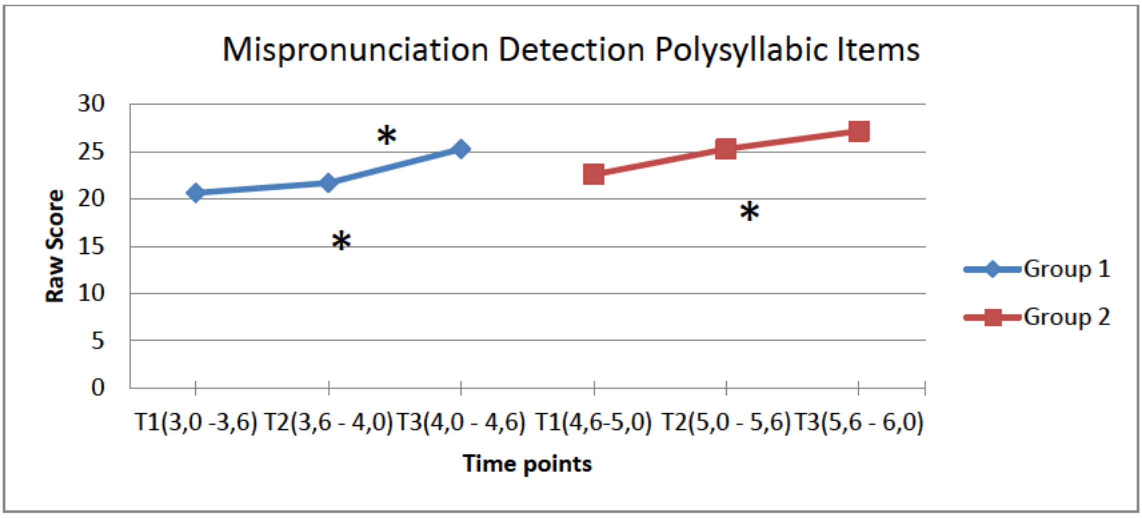

Figure 4-18 Performance on Mispronunciation Detection of Polysyllabic items across time points

It seems that the establishment of accurate phonological representations is quite challenging for children aged 3; 0 – 6; 0. Ceiling effects were not observed for Group 2 even at the last assessment point, indicating that phonological representations are not fully developed by the age of six years. However, it should be acknowledge that performance may be related to factors such as the task difficulty, vocabulary knowledge, and word length. Investigation of these factors and their effect on the development of speech processing skills is the focus of chapter 5.

4.2.4 Is there a difference in performance for children of different ages in accessing accurate motor programs?

In order to assess the accuracy of motor programs, productions given in response to the Renfrew test of word finding (as presented in section 3.3.2.i) were scored on the accuracy of articulation a) on a whole word basis (WW naming) and b) on Percentage of Consonants correct in each word (PCC Naming). Raw scores for WW naming accuracy report the number of correct productions of those words said by a child in the total of 50 test items. However there is the possibility that a child responded to fewer than 50 words, in the occasion that administration of the test was stopped as a result of five consecutive mistakes. In cases where a child gave a semantically incorrect answer, but the response was a single word and the child's own target was clear (for example when asked to name the picture of a duck the child responded that this is a bird), then this response was scored on the accuracy of articulation following the same criteria that were used in scoring productions that corresponded to the semantic targets of the task. Means, standard deviations and ranges for the two groups across time points for naming accuracy scored for WW are presented in Table 4-18 and for PCC are presented in Table 4-19.

Table 4-18 Descriptive statistics for each age group on Naming Accuracy – Whole Word

Group		Age	Total	Mean	Std. Deviation	Minimum Score	Maximum Score	Kolmogorov - Smirnov
1	T1	3;0 – 3;6	50	10.56	7.53	1	28	p= .757
	T2	3;6 – 4;0	50	15.75	9.15	1	30	p= .890
	T3	4;0 – 4;6	50	24.19	11.93	2	45	p= .999
2	T1	4;6 – 5;0	50	25.67	10.35	5	43	p= .936
	T2	5;0 – 5;6	50	30.63	11.19	6	47	p= .966
	T3	5;6 – 6;0	50	35.10	8.34	16	47	p= .934

Table 4-19 Descriptive statistics for each age group on Naming Accuracy – Percentage of Consonants Correct

Group		Age	Total	Mean	Std. Deviation	Minimum Score	Maximum Score	Kolmogorov - Smirnov
1	T1	3;0 – 3;6	100%	74.42	19.82	30.00	95.54	p= .917
	T2	3;6 – 4;0	100%	82.13	17.00	46.48	98.15	p= .458
	T3	4;0 – 4;6	100%	89.83	12.06	53.33	99.15	p= .974
2	T1	4;6 – 5;0	100%	90.24	9.12	61.54	98.06	p= .226
	T2	5;0 – 5;6	100%	91.31	9.56	61.17	100	p= .172
	T3	5;6 – 6;0	100%	94.10	5.30	81.36	100	p= .943

Kolmogorov Smirnov and visual inspection of the histograms reveal that data were normally distributed, so Repeated Measures Anova was used to compare performance.

For Group 1 there was a main effect of time both on whole word naming accuracy ($F_{(2, 14)}$ = 24.09, p<.001) and on PCC accuracy in naming ($F_{(2, 14)}$=14.25, p<.001). Pairwise comparisons (with Bonferroni adjustment for multiple comparisons) yield a significant difference on whole word naming accuracy between T1 and T2 (p=.002), between T2 and T3 (p<.001) and between T1 and T3 (p<.001) as well as a highly significant difference on PCC accurately produced across time points i.e. between T1 and T2 (p=.001), between T2 and T3 (p=.012) and between T1 and T3 (p<.001).

For Group 2 there was a main effect of time on whole word naming accuracy ($F_{(2, 16)}$ =25.11, p<.001) but not on PCC accuracy ($F_{(2, 16)}$=3.54, p=.053). Pairwise comparisons (with Bonferroni adjustment for multiple comparisons) yield a significant difference in whole word naming accuracy between T1 and T2 (p=.001), between T2 and T3 (p=.003) and between T1 and T3 (p<.001).

Performance of the two groups across time points is presented in Figure 4-19 for whole word scoring and in Figure 4-20 for PCC scoring .

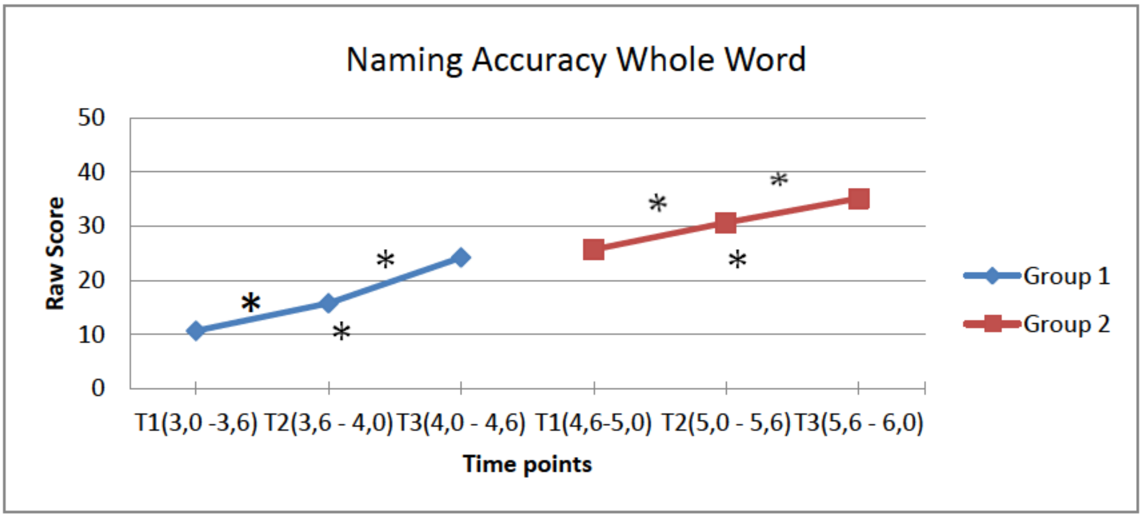

Figure 4-19 Performance on Naming accuracy, whole word scoring across time points

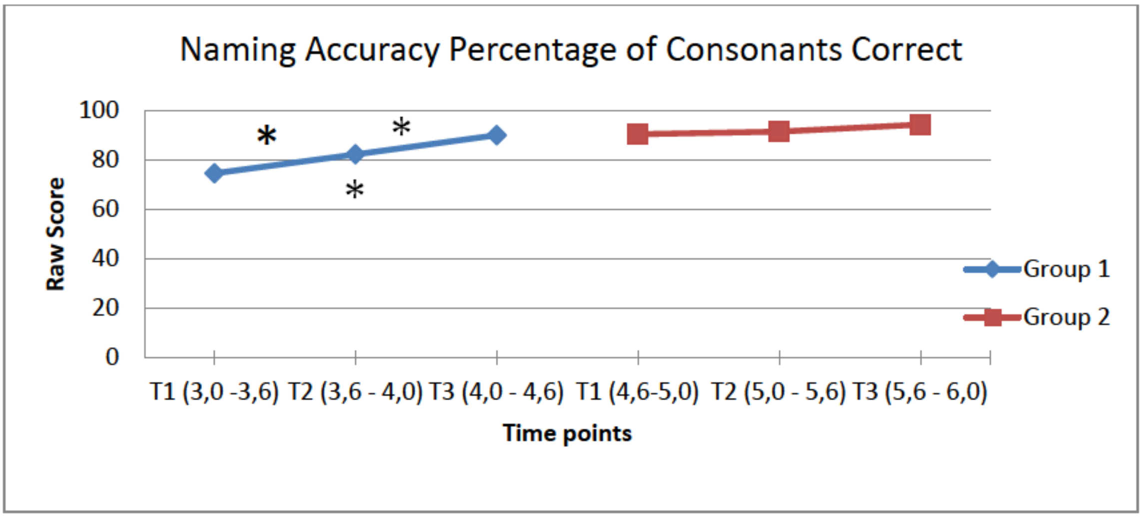

Figure 4-20 Performance on Naming Accuracy, Percentage of Consonants Correct scoring across time points

The accuracy of motor programs, as measured in naming pictures, develops rapidly for Group 1, as shown by statistically significant differences in performance between time points of assessment. However, the large standard deviation in this Group indicates variability in naming accuracy and its development amongst the children in this group.

In contrast for Group 2 it seems that motor programs are mostly well defined, therefore the changes occurring in PCC are not sufficient to result in a significant difference per se. Nevertheless, smaller improvements in consonant accuracy result in a significant difference in whole word scores from one assessment point to the next because the distortion of a single consonant could be relatively unimportant when calculating PCC but, even if it is the only error, would lead to the whole word being scored as incorrect.

It should be kept in mind that naming relies on other output skills (e.g. motor execution) as well as motor programs and so these have potential to affect accuracy. Accuracy of naming is not itself a test of accuracy of motor programs – whether or not the child has accurate motor programs can only be established by considering naming accuracy in the context of results from other output tasks. Performance in real word repetition is presented in the next section.

4.2.5 Is there a difference in performance for children of different ages in producing the phonological and morphological elements of real words accurately?

In order to assess the production of real words with different phonological and/ or morphological characteristics children were asked to complete tasks of i) Real –Word repetition of words of phonological interest (RWRepPhon) as presented in table 3.5 (30 items in total), ii) Real – Word repetition of words of morphological interest (RWRepMor) as presented in table 3.3 (30 items in total) and iii) Repetition of Real Polysyllabic words (RWRepPol) as presented in table 3.7 (21 items in total). Responses were scored on the accuracy of articulation a) on a whole word basis (WW) b) on Percentage of Consonants correct in each word (PCC). Means, standard deviations and ranges for the two groups across time points were calculated for RWRepPhonWW (Table 4-20), RWRepMorWW (Table 4-21), RWRepPolWW (Table 4-22), RWRepPhonPCC (Table 4-23), RWRepMorPCC (Table 4-24) and RWRepPolPCC (Table 4-25).

Table 4-20 Descriptive statistics for each age group for accuracy of Real word Repetition Phonological – Whole Word

Group		Age	Total	Mean	Std. Deviation	Minimum Score	Maximum Score	Kolmogorov - Smirnov
1	T1	3;0 – 3;6	30	17.38	7.77	3	29	p= .756
	T2	3;6 – 4;0	30	20.69	7.11	3	29	p= .870
	T3	4;0 – 4;6	30	24.60	5.95	11	30	p= .073
2	T1	4;6 – 5;0	30	22.50	6.49	7	29	p= .563
	T2	5;0 – 5;6	30	26.79	5.11	10	30	p= .106
	T3	5;6 – 6;0	30	27.00	3.66	18	30	p= .033

Table 4-21 Descriptive statistics for each age group for accuracy of Real word Repetition Morphological – Whole Word

Group		Age	Total	Mean	Std. Deviation	Minimum Score	Maximum Score	Kolmogorov - Smirnov
1	T1	3;0 – 3;6	30	16.50	7.64	1	27	p= .972
	T2	3;6 – 4;0	30	20.88	9.07	2	30	p= .371
	T3	4;0 – 4;6	30	22.93	8.19	6	30	p= .084
2	T1	4;6 – 5;0	30	22.73	5.73	10	29	p= .219
	T2	5;0 – 5;6	30	25.89	7.32	3	30	p= .028
	T3	5;6 – 6;0	30	26.11	5.95	11	30	p= .015

Table 4-22 Descriptive statistics for each age group for accuracy of Real word Repetition Polysyllabic – Whole Word

Group		Age	Total	Mean	Std. Deviation	Minimum Score	Maximum Score	Kolmogorov - Smirnov
1	T1	3;0 – 3;6	21	5,31	4,80	0	14	p= .721
	T2	3;6 – 4;0	21	9,06	6,69	0	21	p= .929
	T3	4;0 – 4;6	21	11,40	7,34	0	21	p= .166
2	T1	4;6 – 5;0	21	11,05	6,19	0	20	p= .529
	T2	5;0 – 5;6	21	15,37	6,09	0	21	p= .200
	T3	5;6 – 6;0	21	17,00	5,98	3	21	p= .047

Table 4-23 Descriptive statistics for each age group for accuracy of Real word Repetition Phonological – Percentage of Consonants Correct

Group		Age	Total	Mean	Std. Deviation	Minimum Score	Maximum Score	Kolmogorov - Smirnov
1	T1	3;0 – 3;6	100%	79,63	16,52	41.56	100	p= .459
	T2	3;6 – 4;0	100%	86,61	12,85	53.25	100	p= .313
	T3	4;0 – 4;6	100%	92,47	9,21	68.83	100	p= .055
2	T1	4;6 – 5;0	100%	92,40	8,17	64.94	100	p= .027
	T2	5;0 – 5;6	100%	95,83	6,84	72.73	100	p= .098
	T3	5;6 – 6;0	100%	96,10	4,76	84.42	100	p= .030

Table 4-24 Descriptive statistics for each age group for accuracy of Real word Repetition Morphological – Percentage of Consonants Correct

Group		Age	Total	Mean	Std. Deviation	Minimum Score	Maximum Score	Kolmogorov - Smirnov
1	T1	3;0 – 3;6	100%	84,40	15,20	39.69	97.71	p= .400
	T2	3;6 – 4;0	100%	90,79	10,51	64.12	100	p= .380
	T3	4;0 – 4;6	100%	93,23	8,57	72.52	100	p= .203
2	T1	4;6 – 5;0	100%	96,04	7,65	68.70	100	p= .252
	T2	5;0 – 5;6	100%	96,02	7,82	68.70	100	p= .061
	T3	5;6 – 6;0	100%	96,48	5,60	83.21	100	p= .027

Table 4-25 Descriptive statistics for each age group for accuracy of Real word Repetition Polysyllabic – Percentage of Consonants Correct

Group		Age	Total	Mean	Std. Deviation	Minimum Score	Maximum Score	Kolmogorov - Smirnov
1	T1	3;0 – 3;6	100%	74,44	19,06	27.03	100	p= .218
	T2	3;6 – 4;0	100%	82,04	19,54	31.53	100	p= .697
	T3	4;0 – 4;6	100%	87,57	12,67	54.95	100	p= .799
2	T1	4;6 – 5;0	100%	89,24	12,52	56.76	100	p= .106
	T2	5;0 – 5;6	100%	93,36	9,99	60.36	100	p= .056
	T3	5;6 – 6;0	100%	95,02	7,59	79.28	100	p= .858

Kolmogorov Smirnov and visual inspection of the histograms reveal that data were normally distributed, so Repeated Measures Anova was used to compare performance.

For Group 1 there was a main effect of time for all RWRep Measurements i.e. RWRepPhonWW ($F_{(2,13)}$=15.08, p<.001), RWRepMorWW ($F_{(2,13)}$=8.71, p=.004), RWRepPolWW ($F_{(2,13)}$=10.80, p<.001), RWRepPhonPCC ($F_{(2,13)}$=12.10, p=.001), RWRepMorPCC ($F_{(2,13)}$=7.58, p=.007) and RWRepPolPCC ($F_{(2,13)}$=15.98, p<.001). Pairwise comparisons (with Bonferroni adjustment for multiple comparisons) yield a significant difference on RWRepPhonWW performance between T1 and T2 (p=.019), between T1 and T3 (p<.001) and between T2 and T3 (p=.019), on RWRepMorWW performance between T1 and T2 (p=.021) and between T1 and T3 (p=.003) and on RWRepPolWW performance between T1 and T2 (p=.006), between T1 and T3 (p<.001) and between T2 and T3 (p=.025), on RWRepPhonPCC performance between T1 and T2 (p=.009), between T1 and T3 (p<.001), between T2 and T3 (p=.021), on RWRepMorPCC performance between T1 and T2 (p=.005) and between T1 and T3 (p=.004) and for RWRepPolPCC performance between T1 and T2 (p=.004) between T1 and T3 (p<.001) and between T2 and T3 (p=.041).

For Group 2 there was a main effect of time for RWRepPhonWW ($F_{(2,16)}$=3.65, p=.049), RWRepMorWW ($F_{(2,16)}$=4.28, p=.048), RWRepPolWW ($F_{(2,14)}$=15.31, p=.032), RWRepPhonPCC ($F_{(2,16)}$=7.08, p=.006), RWRepPolPCC ($F_{(2,14)}$=7.87, p<.001) but not for RWRepMorPCC. Pairwise comparisons (with Bonferroni adjustment for multiple comparisons) yield a significant difference on RWRepPhonWW between T1 and T3 (p=.041), on RWRepPolWW between T1 and T2 (p=.005), between T2 and T3 (p=.009) and between T1 and T3 (p=.001), on RWRepPhonPCC between T1 and T3 (p=.004), between T1 and T2 (p=.028), on RWRepPolPCC between T1 and T2 (p=.049) and between T1 and T3 (p=.018). Main effect of time just reached significance (p=.048) for RWRepMorWW, but there was not a significant different identified in comparison of performance between different time points.

Performance of the two groups across time points for RWRepPhonWW is presented in Figure 4-21, for RWRepMorWW is presented in Figure 4-22, for RWRepPolWW is presented in Figure 4-23, for RWRepPhonPCC is presented in Figure 4-24, for RWRepMorPCC is presented in Figure 4-25 and for RWRepPolPCC is presented in Figure 4-26.

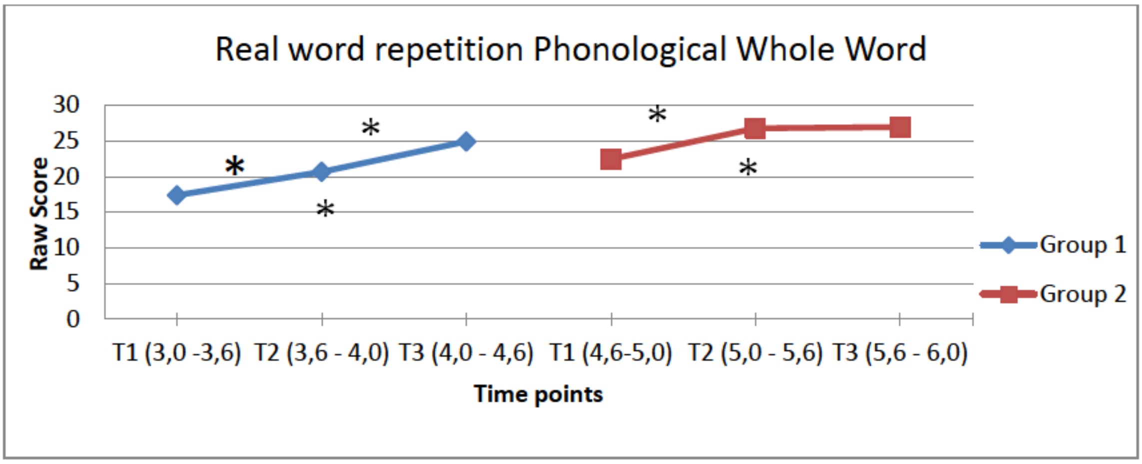

Figure 4-21 Performance on Real Word Repetition of Phonological items, whole word scoring across time points

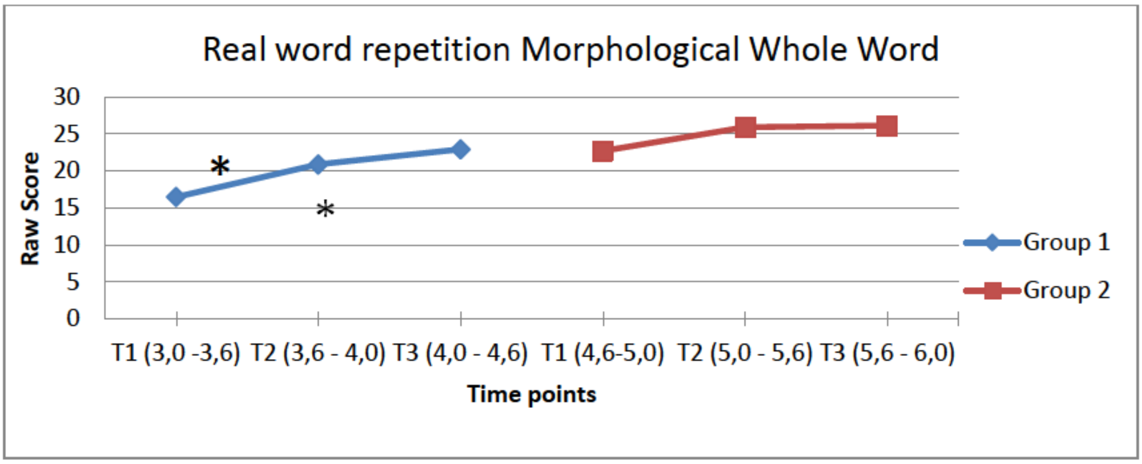

Figure 4-22 Performance on Real Word Repetition of Morphological items, whole word scoring across time points

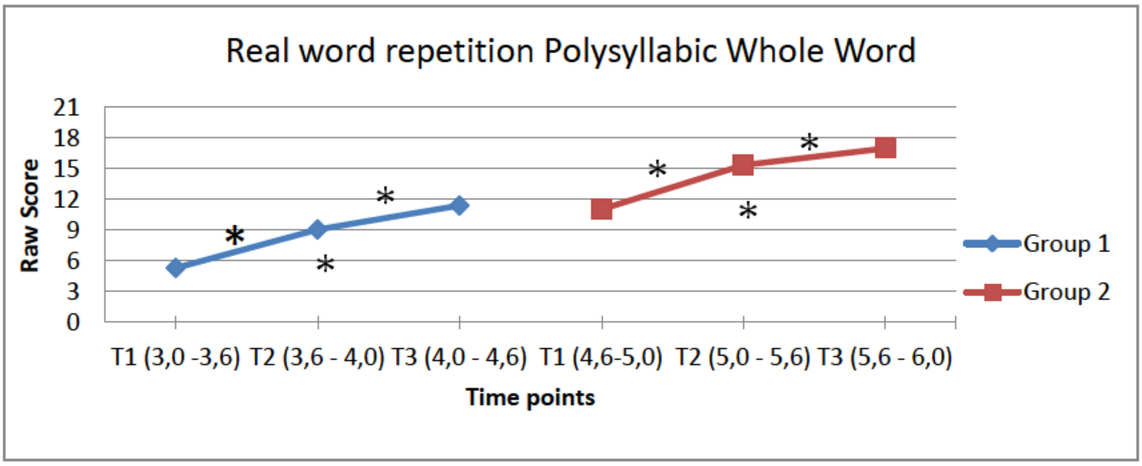

Figure 4-23 Performance on Real Word Repetition of Polysyllabic items, whole word scoring across time points

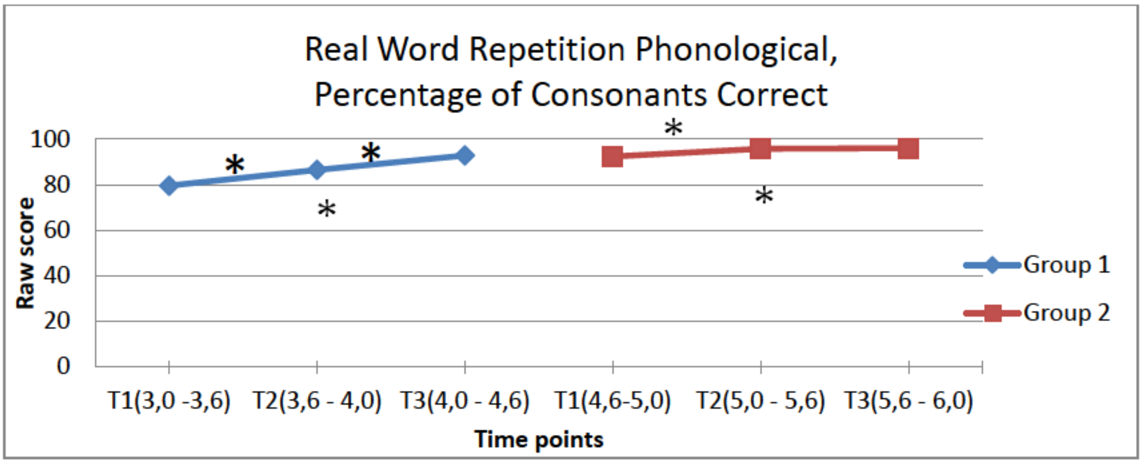

Figure 4-24 Performance on Real Word repetition of Phonological items, Percentage of Consonants Correct scoring across time points

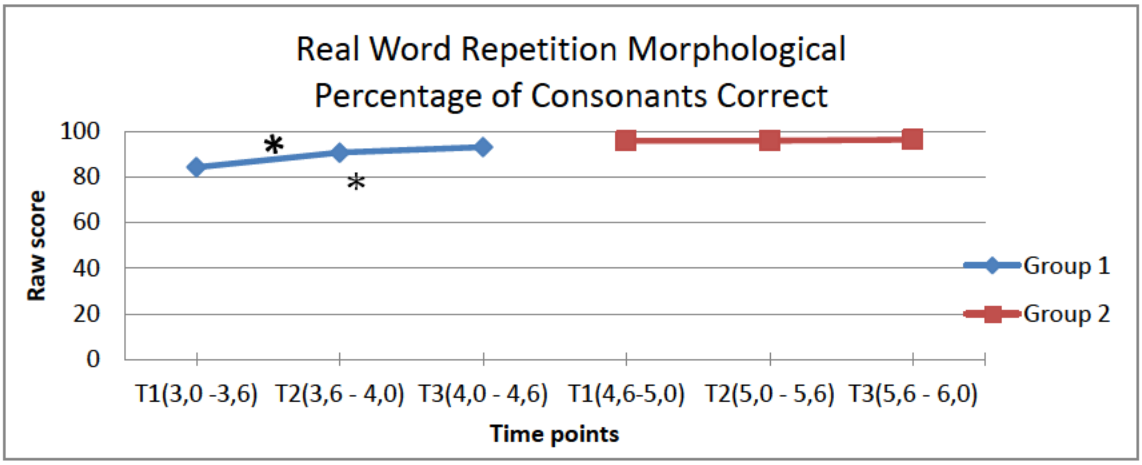

Figure 4-25 Performance on Real Word repetition of Morphological items, Percentage of Consonants Correct scoring across time points

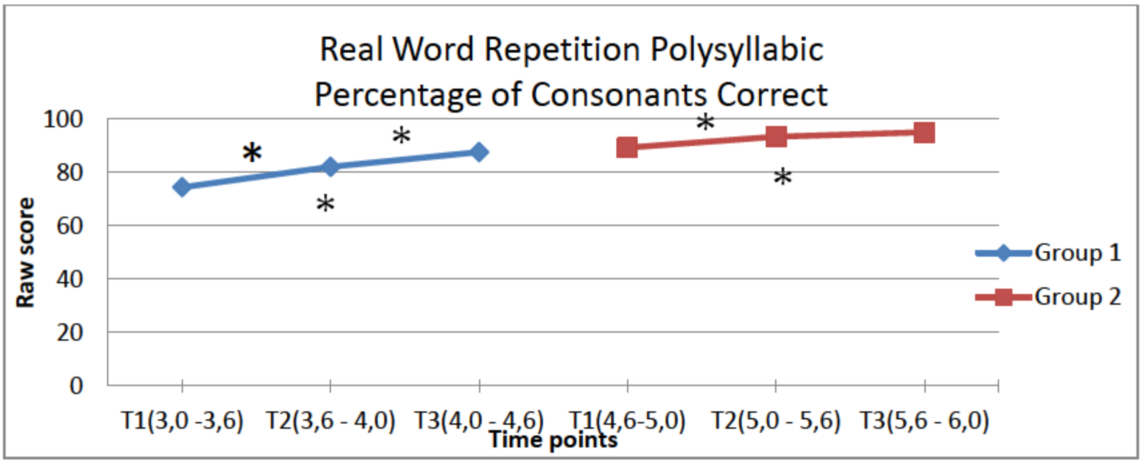

Figure 4-26 Performance on Real Word repetition of Polysyllabic Words, Percentage of Consonants Correct scoring across time points

It seems that the tasks of RWRep are sensitive enough to detect developmental changes in children aged 3.0 to 6.0 years. Real word stimuli enable children to access stored motor programs to complete the task. However, it is possible for a child to repeat a word without accessing stored representations, treating it as a nonword. In the latter case a sublexical route is used, entailing the assembly of a new motor program. Comparison of performance in different output tasks such as naming, real word and nonword repetition allows hypothesis testing on the preferred strategy in repetition performance. Therefore, it is important to have a developmentally sensitive assessment of real word repetition performance. Results in nonword repetition performance are presented in the next section. The role of phonological and morphological characteristics in real word repetition is explored in Chapter 5.

4.2.6 Is there a difference in performance for children of different ages in producing speech without reference to phonological and morphological representations?

In order to assess the production of different phonological and/ or morphological characteristics without reference to representations children were asked to complete tasks of Non –Word repetition (NWRep) of i) phonological interest (Phon) as presented in table 3-6 (30 items in total), ii) of morphological interest (Mor) as presented in table 3-4 (30 items in total) and iii) of Polysyllabic items (Pol) as presented in table 3-7 (21 items in total). Responses were scored on the accuracy of articulation a) on a whole word basis (WW) and b) on Percentage of Consonants correct in each word (PCC). Means, standard deviations and ranges for the two groups in NWRep tasks across time points were calculated for NWRepPhonWW (Table 4-26), NWRepMorWW (Table 4-27), NWRepPolWW (Table 4-28), NWRepPhonPCC (Table 4-29), NWRepMor PCC (Table 4-30) and NWRepPolPCC (Table 4-31).

Table 4-26 Descriptive statistics for each age group for accuracy of Non - Word Repetition Phonological – Whole Word

Group		Age	Total	Mean	Std. Deviation	Minimum Score	Maximum Score	Kolmogorov - Smirnov
1	T1	3;0 – 3;6	30	16.19	7.54	0	26	p= .302
	T2	3;6 – 4;0	30	19.75	7.13	3	28	p= .707
	T3	4;0 – 4;6	30	22.53	5.96	9	27	p= .252
2	T1	4;6 – 5;0	30	23.80	5.46	7	30	p= .248
	T2	5;0 – 5;6	30	25.32	5.19	9	30	p= .024
	T3	5;6 – 6;0	30	25.67	4.46	15	30	p= .097

Table 4-27 Descriptive statistics for each age group for accuracy of Non - Word Repetition Morphological – Whole Word

Group		Age	Total	Mean	Std. Deviation	Minimum Score	Maximum Score	Kolmogorov - Smirnov
1	T1	3;0 – 3;6	30	14.75	7.34	1	25	p= .964
	T2	3;6 – 4;0	30	19.69	7.74	2	28	p= .605
	T3	4;0 – 4;6	30	21.73	7.96	5	27	p= .084
2	T1	4;6 – 5;0	30	23.47	7.97	4	30	p= .146
	T2	5;0 – 5;6	30	24.00	7.12	5	29	p= .298
	T3	5;6 – 6;0	30	24.37	6.44	9	30	p= .015

Table 4-28 Descriptive statistics for each age group for accuracy of Non - Word Repetition Polysyllabic – Whole Word

Group		Age	Total	Mean	Std. Deviation	Minimum Score	Maximum Score	Kolmogorov - Smirnov
1	T1	3;0 – 3;6	30	4.25	3.79	0	11	p= .799
	T2	3;6 – 4;0	30	8.00	6.56	0	18	p= .759
	T3	4;0 – 4;6	30	10.07	6.51	0	20	p= .896
2	T1	4;6 – 5;0	30	10.45	5.46	0	18	p= .858
	T2	5;0 – 5;6	30	12.95	5.81	0	21	p= .332
	T3	5;6 – 6;0	30	15.33	6.15	1	21	p= .545

Table 4-29 Descriptive statistics for each age group for accuracy of Non - Word Repetition Phonological – Percentage of Consonants Correct

Group		Age	Total	Mean	Std. Deviation	Minimum Score	Maximum Score	Kolmogorov - Smirnov
1	T1	3;0 – 3;6	100%	77.68	15.84	37.66	94.81	p=.125
	T2	3;6 – 4;0	100%	84.17	15.08	46.75	97.40	p= .331
	T3	4;0 – 4;6	100%	89.44	9.12	67.53	96.10	p= .382
2	T1	4;6 – 5;0	100%	90.94	8.48	61.04	100	p= .060
	T2	5;0 – 5;6	100%	94.05	6.93	70.13	100	p= .017
	T3	5;6 – 6;0	100%	95.08	4.85	84.42	100	p= .175

Table 4-30 Descriptive statistics for each age group for accuracy of Non - Word Repetition Morphological – Percentage of Consonants Correct

Group		Age	Total	Mean	Std. Deviation	Minimum Score	Maximum Score	Kolmogorov - Smirnov
1	T1	3;0 – 3;6	100%	77.23	17.30	26.73	94.06	p= .603
	T2	3;6 – 4;0	100%	86.57	12.56	52.48	98.02	p= .541
	T3	4;0 – 4;6	100%	89.44	11.47	59.41	97.03	p= .057
2	T1	4;6 – 5;0	100%	92.29	11.31	56.44	92.28	p= .307
	T2	5;0 – 5;6	100%	92.92	10.62	57.43	92.92	p= .039
	T3	5;6 – 6;0	100%	92.85	8.61	73.27	92.85	p= .075

Table 4-31 Descriptive statistics for each age group for accuracy of Non - Word Repetition Polysyllabic– Percentage of Consonants Correct

Group		Age	Total	Mean	Std. Deviation	Minimum Score	Maximum Score	Kolmogorov - Smirnov
1	T1	3;0 – 3;6	100%	69.76	18.19	24.32	100	p= .157
	T2	3;6 – 4;0	100%	80.01	16.24	37.84	98.20	p= .853
	T3	4;0 – 4;6	100%	86.01	13.30	48.65	99.10	p= .580
2	T1	4;6 – 5;0	100%	86.91	11.33	55.86	100	p= .256
	T2	5;0 – 5;6	100%	91.13	10.63	55.86	100	p= .257
	T3	5;6 – 6;0	100%	92.98	9.20	67.57	100	p= .220

Kolmogorov Smirnov and visual inspection of the histograms reveal that data were normally distributed, so Repeated Measures Anova was used to compare performance.

For Group 1 there was a main effect of time for all NW Repetition Measurements i.e. NWRepPhonWW ($F_{(2,13)}$=11.71, p=.001), NWRepMorWW ($F_{(2,13)}$=19.16, p<.001), NWRepPolWW ($F_{(2,13)}$=20.83, p<.001), PCC NW Rep Phon ($F_{(2,13)}$=10.44, p=.002), PCC NW Rep Mor ($F_{(2,13)}$=13.10, p<.001), PCC NW Rep Pol ($F_{(2,13)}$=24.81, p<.001). Pairwise comparisons (with Bonferroni adjustment for multiple comparisons) yield a significant difference on NWRepPhonWW performance between T1 and T2 (p=.005), between T1 and T3 (p=.001) and between T2 and T3 (p=.027), on NWRepMorWW performance between T1 and T2 (p<.001), between T1 and T3 (p<.001), on NWRepPol performance between T1 and T2 (p=.011), between T1 and T3 (p<.001) and between T2 and T3 (p=.001), on NWRepPhonPCC between T1 and T2 (p=.005), between T1 and T3 (p=.001) and between T2 and T3 (p=.045), on NWRepMorPCC performance between T1 and T2 (p=.001), between T1 and T3 (p<.001) and between T2 and T3 (p=.021), on NWRepPolPCC performance between T1 and T2 (P<.001), between T1 and T3 (p<.001) and between T2 and T3 (p<.001).

For Group 2 there was a main effect of time for NWRepPolWW ($F_{(2,14)}$=14.49, p<.001), NWRepPhonPCC ($F_{(2,17)}$=6.07, p=.010), NWRepMorPCC ($F_{(2,14)}$=4.89, p=.025) and NWRepPolPCC ($F_{(2,16)}$=6.50, p<.009). Pairwise comparisons (with Bonferroni adjustment for multiple comparisons) yield a significant difference on NWRepPolWW performance between T1 and T3 (p=.006) and between T2 and T3 (p<.001), on NWRepPhonPCC between T1 and T2 (p=.007) and between T1 and T3 (p=.026), on NWRepMorPCC between T1 and T2 (p=.019) and on NWRepPolPCC between T1 and T3 (p=.009)

Performance of the two groups across time points for NWRepPhonWW is presented in Figure 4-27, for NWRepMorWW is presented in Figure 4-28, for NWRepPolWW is presented in Figure 4-29, for NWRepPhonPCC is presented in Figure 4-30, for NWRepMorPCC is presented in Figure 4-31 and for NWRepPolPCC is presented in Figure 4-32.

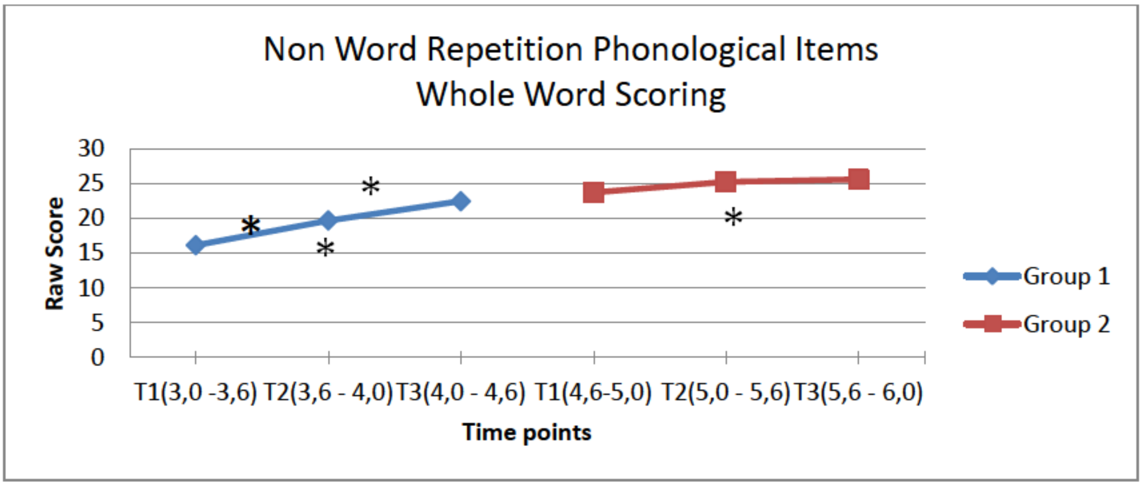

Figure 4-27 Performance on production of speech sounds without reference to phonological representations whole word scoring across time points

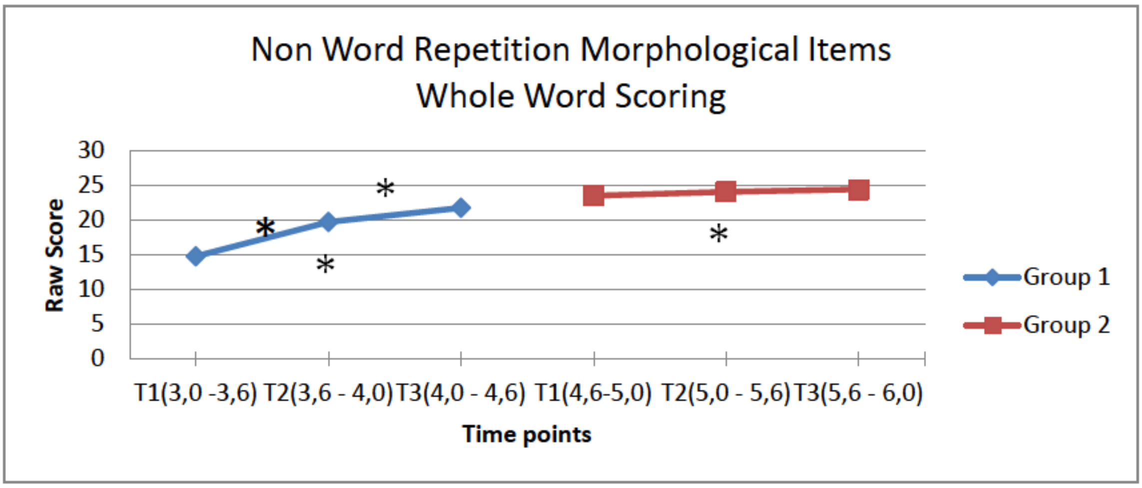

Figure 4-28 Performance on production of speech sounds without reference to morphological representations whole word scoring across time points

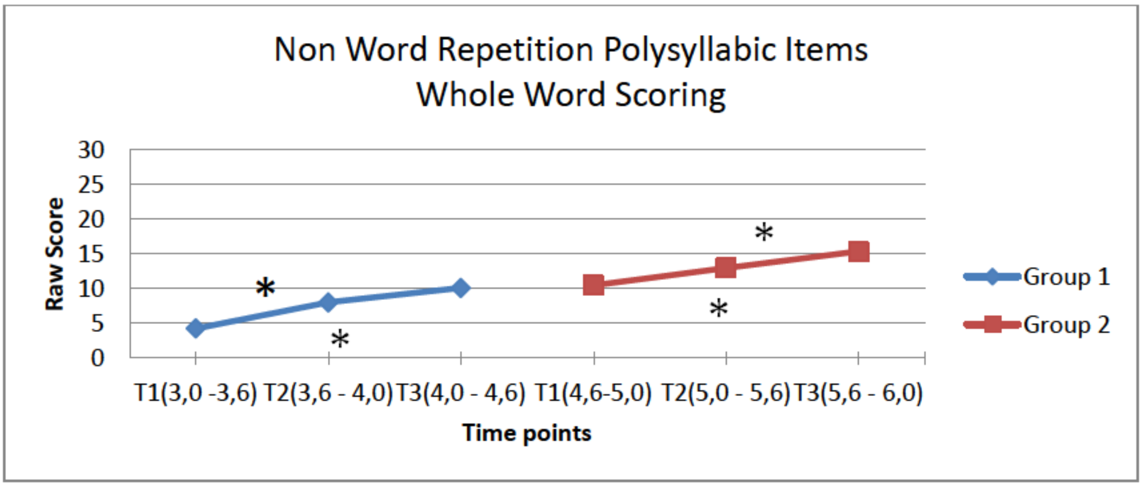

Figure 4-29 Performance on production of speech sounds without reference to representations for polysyllabic items whole word scoring across time points

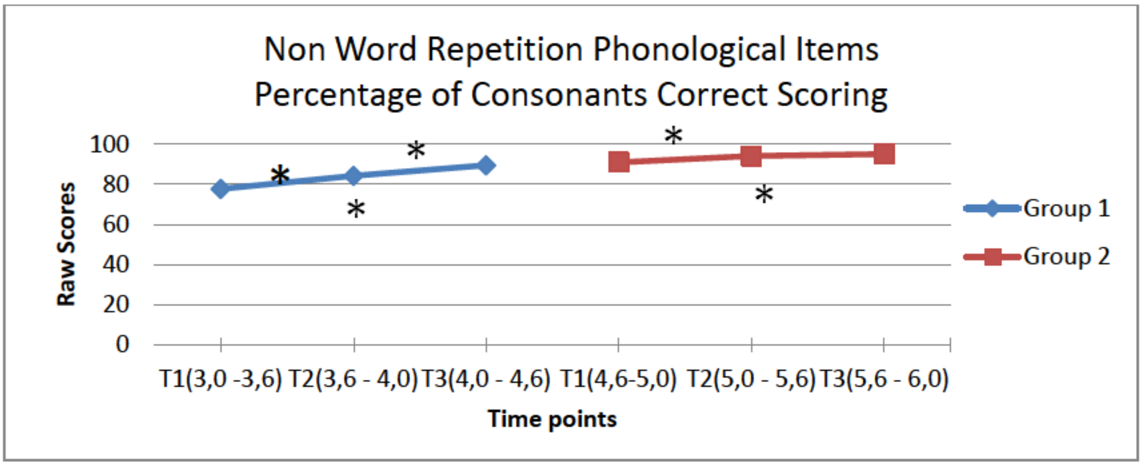

Figure 4-30 Performance on production of speech sounds without reference to phonological representations, percentage of consonants correct scoring across time points

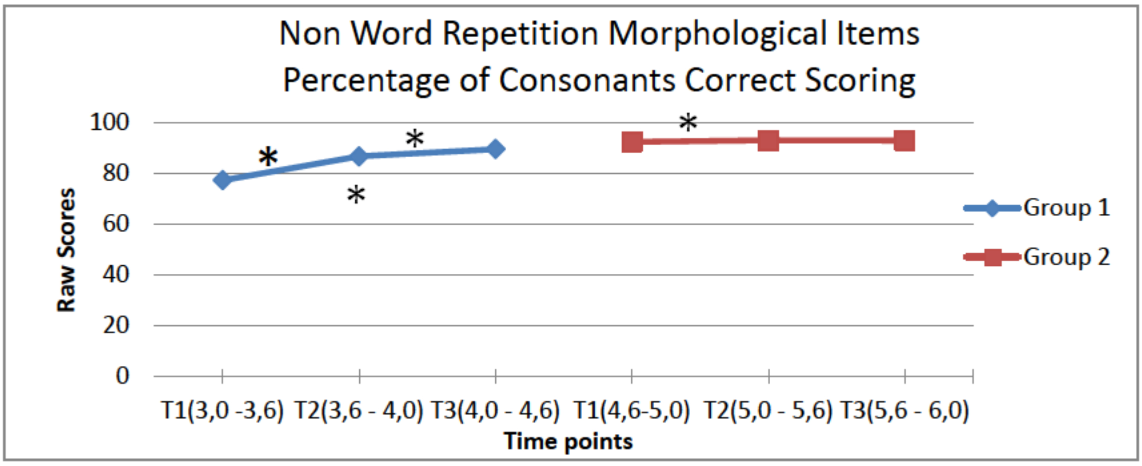

Figure 4-31 Performance on production of speech sounds without reference to morphological representations, percentage of consonants correct scoring across time points

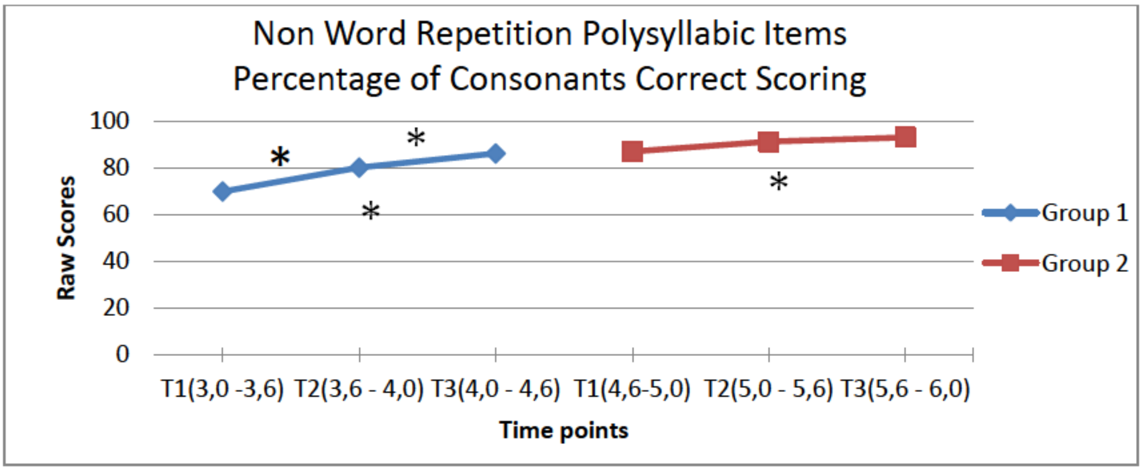

Figure 4-32 Performance on production of speech sounds without reference to representations for polysyllabic items percentage of consonants correct scoring across time points

Highly significant differences in performance are evident between assessment points for all the tasks for Group 1. The percentage of consonants correct appears to be in early childhood an extremely sensitive marker for speech production skills without reference to representations.

Performance of Group 2 seems to be characterized by ceiling effects. Statistically significant differences in performance are mainly found between T1 and T3.

4.3 Development of phonological awareness abilities over time

The current section seeks to investigate the development of phonological awareness abilities in typically developing Greek speaking children, aged 3;0 -6;0, for which little information is available. In order to assess the development of phonological awareness a published silent blending task and an experimental segmentation task were used. It is hypothesized that there will be significant difference in PA assessment performance within each age group between testing points on:

a) Sound blending
b) segmentation

4.3.1 Development of blending abilities

In order to assess the ability to compose words from the constituent individual phonemes or syllables children were asked to complete a silent Blending Task (Blend) as presented in section 3.3.3. For example the child hear /p/-/u/-/l/-/i/ and was expected to point to [puˈli] (bird) in a series of four pictures. In the case where a child was not able to choose the correct picture following phoneme presentation, in a second attempt syllables were used instead of phonemes for example /pu/-/li/. The complete set of task items can be seen in Appendix 4. Responses were scored for the correct picture selection. When a child chose the correct picture based on phoneme presentation of the target a point was given (possible total 10). When a child chose the correct picture based on syllable presentation of the target, a half point was given (the possible total for accurate picture choice for all task items following a syllable presentation is therefore 5). A score of more than five indicates that the child was able, at least for some of the task items, to blend phonemes. Means, standard deviations and ranges for the two groups in silent blending task across time points are presented in Table 4-32 .

Table 4-32 Descriptive statistics for each age group on blending tasks

Group		Age	Total	Mean	Std. Deviation	Minimum Score	Maximum Score	Kolmogorov - Smirnov
1	T1	3;0 – 3;6	10	4.53	.59	3.0	5.0	p= .145
	T2	3;6 – 4;0	10	5.66	1.67	4.5	9.0	p= .020
	T3	4;0 – 4;6	10	7.90	1.48	5.0	9.5	p= .932
2	T1	4;6 – 5;0	10	7.57	1.61	5.0	10	p= .817
	T2	5;0 – 5;6	10	8.21	1.55	5.0	10	p= .550
	T3	5;6 – 6;0	10	9.19	1.06	6.5	10	p= .127

Kolmogorov Smirnov and visual inspection of the histograms reveal that data were normally distributed, so Repeated Measures Anova was used to compare performance.

For Group 1 there was a main effect of time on blending performance ($F_{(2, 13)}$=30.32, p<.001). Pairwise comparisons (with Bonferroni adjustment for multiple comparisons) yielded a significant difference in performance between T1 and T3 (p<.001) and between T2 and T3 (p<.001).

For Group 2 there was a main effect of time on blending performance ($F_{(2, 16)}$=8.33, p=.033. Pairwise comparisons (with Bonferroni adjustment for multiple comparisons) yielded a significant difference in performance between T1 and T3 (p=.004)

Performance of the two groups across time points on Blending is presented in Figure 4-33.

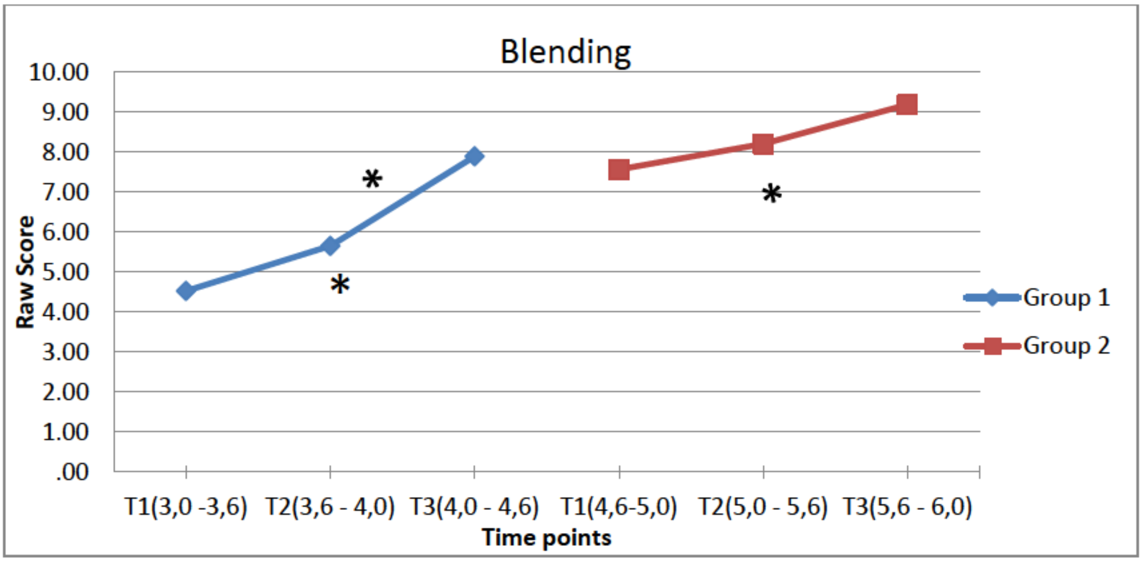

Figure 4-33 Performance on Blending task across time points

For Group 1 it seems that blending syllables into words emerges after T1 and that there is substantial development between T2 and T3. For Group 2 blending syllables is well developed and blending phonemes is gradually emerging at a slow rate, as indicated by significant improvement in performance between T1 and T3.

4.3.2 Development of segmentation abilities

In order to assess the ability to segment words into constituent syllables or phonemes children were asked to complete an experimental task of word segmentation. A word was given orally for example [puˈli] and the child was asked to segment this word. The complete set of task items can be seen in Table 3-9. Responses were scored on graded scale (as presented in section 3.6.10) depending on whether words were fully (2 points) or partially (1 point) analyzed and whether the segmentation was at the level of phoneme (2 points) or syllable (1 point). A score of less than 17 indicates that some of the task items were not segmented at all. A score above 17 indicates that some of the task items were segmented, in syllables. A score of more than 34 indicates that some of the segmentation was into phonemes. A full score of 68 indicates that all the items were accurately segmented into constituent phonemes. Means, standard deviations and ranges for the two groups in segmentation task across time points are presented in Table 4-33.

Table 4-33 Descriptive statistics for each age group on Segmentation Task

Group		Age	Total	Mean	Std. Deviation	Minimum Score	Maximum Score	Kolmogorov - Smirnov
1	T1	3;0 – 3;6	68	17,63	13,13	0	33	p=.783
	T2	3;6 – 4;0	68	31,69	3,98	21	38	p= .668
	T3	4;0 – 4;6	68	34,13	10,64	31	50	p= .025
2	T1	4;6 – 5;0	68	35,59	12,15	0	61	p= .254
	T2	5;0 – 5;6	68	37,45	12,91	31	66	p= .138
	T3	5;6 – 6;0	68	39,90	16,91	32	65	p= .287

Kolmogorov Smirnov and visual inspection of the histograms reveal that data were normally distributed, so Repeated Measures Anova was used to compare performance.

For Group 1 there was a main effect of time on segmentation performance ($F_{(2,\ 14)}$=12.86, p=.001). Pairwise comparisons (with Bonferroni adjustment for multiple comparisons) yielded a significant difference in performance between T1 and T2 (p=.001) and between T1 and T3 (p<.001). For the Group 2 there was not a main effect of time (F (2, 18) =.832, p=.451).

Performance of the two groups across time points on Segmentation is presented in Figure 4-34.

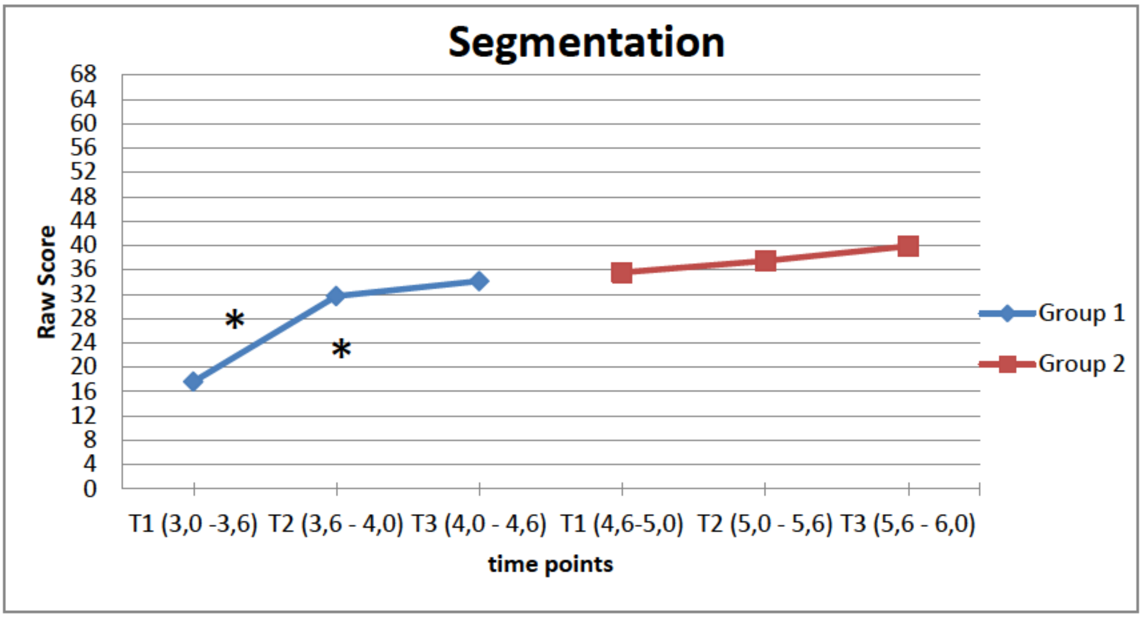

Figure 4-34 Performance on segmentation task across time points

For Group 1 it seems that the ability of segmentation of words into syllables emerges after T1 and that there is substantial development between T1 and T2. For Group 2 segmentation into syllables is well developed and segmentation in phonemes is emerging, however at a slow rate of development. It seems that upon acquisition of syllable segmentation there is a plateau in development and children of this age do not progress to phoneme segmentation. Inspection of the means indicates continuous increase, which is not to such an extent as to be statistically significant. The values of standard deviation show a wide fluctuation in performance among children of the same group.

4.4 Development of Short Term Memory

The current section seeks to investigate the development of Short Term Memory skills in typically developing Greek speaking children, aged 3;0 -6;0, for which little information is available. In order to assess the development of Short Term Memory children were asked to repeat sequences of words, with a gradually increasing number of words, for example two word lists, three word lists, four word lists. The complete set of stimuli used in the task can be seen in Table 3.10. Performance was scored on the number of words recalled from a sequence of words (STM W) and on the number of word lists repeated in the correct order (STM O). Means, standard deviations and ranges were calculated for the two groups in STMW (Table 4-34) and STMO (Table 4-35).

Table 4-34 Descriptive statistics for each age group on STM number of Words recalled

Group		Age	Total	Mean	Std. Deviation	Minimum Score	Maximum Score	Kolmogorov - Smirnov
1	T1	3;0 – 3;6	108	18.00	10.22	4	40	p= .489
	T2	3;6 – 4;0	108	29.19	13.85	6	69	p= .411
	T3	4;0 – 4;6	108	39.67	14.80	18	71	p= .737
2	T1	4;6 – 5;0	108	36.05	11.99	19	74	p= .853
	T2	5;0 – 5;6	108	43.21	9.60	22	74	p= .278
	T3	5;6 – 6;0	108	48.00	11.47	26	78	p= .081

Table 4-35 Descriptive statistics for each age group on STM number of word chunks recalled in the correct Order

Group		Age	Total	Mean	Std. Deviation	Minimum Score	Maximum Score	Kolmogorov - Smirnov
1	T1	3;0 – 3;6	28	4.93	3.31	0	10	p= .425
	T2	3;6 – 4;0	28	8.13	3.56	2	17	p= .393
	T3	4;0 – 4;6	28	18.00	10.22	4	15	p= .902
2	T1	4;6 – 5;0	28	10.29	2.55	7	17	p= .586
	T2	5;0 – 5;6	28	11.32	2.73	6	19	p= .496
	T3	5;6 – 6;0	28	36.05	11.99	9	18	p= .778

Kolmogorov Smirnov and visual inspection of the histograms reveal that data were normally distributed, so Repeated Measures Anova was used to compare performance.

For Group 1 there was a main effect of time on STMW ($F_{(2, 12)}$= 20.14, p<.001) and on STMO ($F_{(2, 12)}$= 26.94, p<.001). Pairwise comparisons (with Bonferroni adjustment for multiple comparisons) yielded a significant difference in performance on STMW between T1 and T2 (p=.008), between T1 and T3 (p<.001) and between T2 and T3 (p=.008) and significant difference in performance on STMO between T1 and T2 (p=.001), between T1 and T3 (p<.001) and between T2 and T3 (p=.033).

For Group 2 there was a main effect of time on STM W ($F_{(2,15)}$=6.70, p=.008 and on STM O ($F_{(2,15)}$=9.03, p=.003). Pairwise comparisons (with Bonferroni adjustment for multiple comparisons) yielded a significant difference in performance on STM W between T1 and T2 (p=.038) and between T1 and T3 (p=.006) and on STM O a significant difference between T1 and T3.

Performance of the two groups across time points on STMW is presented in Figure 4-35 and on STMO is presented in Figure 4-36.

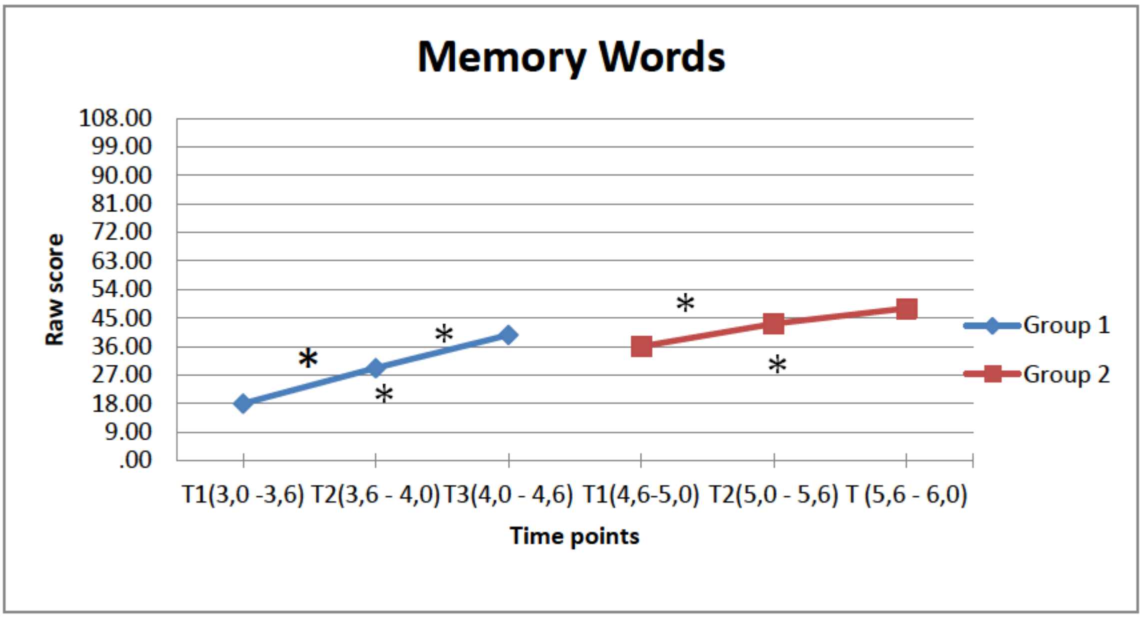

Figure 4-35 Performance on the number of words correctly recalled across time points

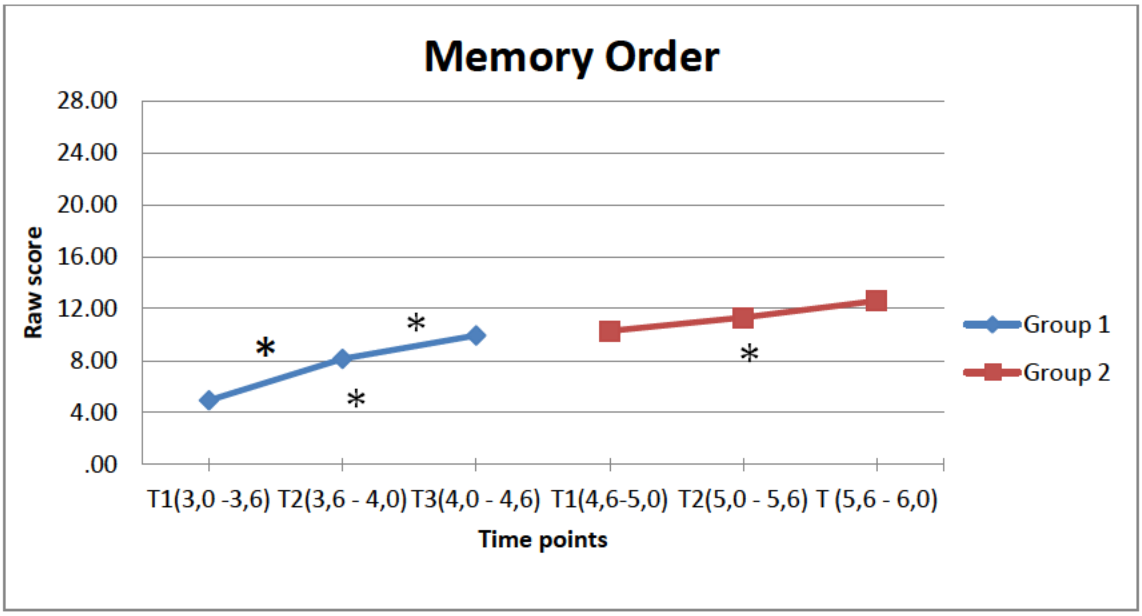

Figure 4-36 Performance on the number of word chunks recalled in the correct order across time points

It seems that STM skills of Group 1 develop significantly from one assessment point to the next, both for the number of words to be recalled and the order of those words in a list. For Group 2 growth of memory capacity is observed, however in a slower rate. Repetition of word lists with more than three words in the correct word order appears to be relatively challenging.

4.5 Summary of findings

A normative study was conducted to investigate how typically developing children perform on a range of tasks and what is the course of development of language, speech processing, phonological awareness and STM skills. For Greek-speaking children aged 3.0 to 6.0 years, prior to this study there was little available data realing to these areas. In both groups of children investigated longitudinally, a strong time effect was found in the development of language skills, of speech processing abilities including phonological awareness, and of short term memory. This indicates that the experimental tasks are developmentally sensitive. In particular, it seeks to provide a description of the development of speech processing skills in typically developing Greek speaking children

With regard to the development of language abilities, statistically significant differences were observed for Group 1 in the course of six months i.e. between T1 and T2 or T2 and T3. For Group 2 statistically significant differences were mainly observed over the course of a year i.e. between T1 and T3 in tasks such as language comprehension, language production, grammar score in elicited language production and narratives.

With regard to the processing of speech input, for Group 1 performance fluctuated below the level of chance in auditory discrimination tasks. Nevertheless statistically significant differences were observed as children got older. When real word stimuli were used significant difference was observed between T1 and T2, whilst when nonword stimuli were used a significant difference was only observed between T2 and T3. Data indicate that a higher performance was achieved in tasks involving real words, as compared to the corresponding tasks involving nonwords. Such discrepancies in performance will be further explored in Chapter 5.

As indicated by the Picture Choice task, a lexical decision task where only one auditory stimulus was provided, young children performed above the level of chance from Group 1 T2 onwards. However, children did not reach ceiling at the age of 5; 6 – 6; 0. Performance on Mispronunciation Detection indicates that Group 1 participants performed below chance. Statistically significant change was observed in performance of both groups between T1 and T3.

With regard to speech output a strong time effect was found in tasks of naming, real word repetition and nonword repetition. Children seem to perform better on tasks including real words rather than nonwords and on morphological rather than phonological items. It also seems that children perform better on tasks requiring repetition rather than spontaneous naming of real words. The possible effects of lexicality and linguistic domain will be further explored in Chapter 5.

With regard to phonological awareness, statistically significant change in blending is observed between T1 and T3 for both groups. Syllable segmentation performance improved significantly between 3;6 – 4;0.

As for short term memory skills, there was a main effect of time both on the number of words as well as the number of word lists to be recalled in the correct order that the children are able to repeat. By the age of three children are able to repeat word lists with increasing number of words included in each block

Further investigation of the factors affecting the performance of children, such as phonological and morphological characteristics of stimuli used in the same level of processing, the development of vocabulary and auditory discrimination skills, and the role of short-term memory in speech processing and language development will be presented in Chapter 5.

Chapter 5. Factors affecting the development of speech and language in Greek speaking children

In Chapter 4 data from typically developing Greek-speaking children were analyzed in terms of the development of specific abilities over time. The speech processing tasks used were shown to be developmentally sensitive. Those results provide the basis for the analyses presented in the current chapter, the aim of which is to identify possible factors affecting the children's performance and potential relationships between different abilities as they develop. This is central to addressing one of the main aims of the thesis, namely to investigate the development of morphology in relation to the development of other speech processing skills, as a part of the speech processing system.

The first part of the present chapter seeks to identify possible factors affecting the development of language, speech processing, phonological awareness and short term memory skills by comparing performance at different levels. The role of prior linguistic knowledge in task completion will be investigated, for example by comparing performance in an otherwise identical pair of tasks where either real words or nonwords are used. Statistical comparison of results of different task pairs is a legitimate way to identify differences in the children's speech processing skills within and across time. Dissociations between tasks presented in the following sections illuminate whether distinct processing components or routes exist in the developing speech processing system. It is not a comparison between different levels of difficulty of the two tasks. For example when real words and matched nonword stimuli are used in repetition, task demands in terms of memory and articulatory complexity are equal. The tasks of real and nonword repetition differ in one dimension, i.e. whether children may access stored lexical representations or not. Differences observed in performance between tasks can be attributed to differences in speech processing demands rather than difficulty of the tasks.

The focal point of the current project is to investigate the development of morphology in relation to the development of speech processing skills. The following analysis seeks to identify similarities and differences between morphological and phonological development. Therefore the possible factors to be investigated are:

1. *Linguistic domain*. It will be investigated whether the stimulus characteristics, namely differences of a phonological or a morphological nature, can affect the performance of children. Inspection of the descriptive statistics in Chapter 4 indicates that in Auditory discrimination tasks (sections 4.2.2 and 4.2.3) children scored higher on morphological than on phonological items in processing real words and matching nonwords. However, it is predicted that factor analysis will show that this difference is not significant. This expectation stems from the theoretical argument of Crystal (1987) that the language system works as a whole unit with interactions between linguistic levels, as well as the proposal of Chiat (2001) that phonological processing lies at the roots of language development. It is likely that comparable skills are involved in input processing of both phonological and morphological characteristics of stimuli to which a child is exposed.
2. *Word length.* Given the findings of James, van Doorn, & McLeod (2008) that speech errors may only be apparent in polysyllabic words and Gathercole, Willis, Emslie, & Baddeley (1991)'s finding that stimulus length affects performance in nonword repetition, it is hypothesized that there will be a word length effect in speech processing, namely: Performance on items of 2-3 syllables will be significantly better than performance on polysyllabic items (i.e. items of more than three syllables).
3. *Lexicality*. It will be investigated whether potential access to representations affects performance. According to the descriptive statistics presented in Chapter 4, children scored higher on auditory discrimination tasks requiring processing of real words (section 4.2.3) in comparison to nonwords (section 4.2.2). In repetition tasks, children seemed to perform better on tasks including real words (section 4.2.6) in comparison to nonwords (section 4.2.7). Given the findings of Vance, Stackhouse, & Wells (2005) that existing lexical representations have a beneficial effect in output processing for four year old children, it is hypothesized that performance on real words (both of phonological and morphological interest) will be significantly better than performance on nonwords (derived from words of both phonological and morphological interest.
4. *Level of processing.* Given the findings of Sutherland & Gillon (2007) that tasks requiring access to representations are more demanding compared to tasks where stored information can be used but it is not essential for the completion of the task, it is hypothesized that there will be an effect of the level of processing on speech processing. It is expected that performance accuracy on real word auditory

discrimination (ABX task) that does not require access to representations will be significantly better than performance on auditory discrimination with picture choice task that requires access to representations.

5. *Modality of processing*. According to Rees (2001) levels of processing are connected and the speech processing system is working as an entity. Research data indicate that children with speech sound disorders (Rvachew & Grawburg, 2006; Edwards et al. 2002) and children with language impairment (Ziegler, Pech-Georgel, George, & Lorenzi, 2011) experience difficulties with speech perception. On the basis that intact speech perception is essential for the appropriate development of speech and language skills, it is predicted that factor analysis will not show a significant difference between performance on auditory discrimination and repetition performance accuracy when same real word stimuli are used.

The second part of this chapter seeks to explore relationships between language, speech processing, phonological awareness and short term memory skills. The longitudinal design of this study allows the investigation of development over time. Correlational analysis will investigate:

1. *The relationship between processing of phonological and processing of morphological items.* If the processing of phonological items and the processing of morphological items pose similar demands for the speech processing system, then there may be a relationship between processing of phonological and morphological items when the level and modality of processing are similar. Mastropavlou (2010) provided evidence that in Greek speaking children phonology may have a facilitatory role in the acquisition of morphology. Therefore it will be investigated if there is a relationship between processing of phonological and morphological items within and across time.
2. *The relationship between input processing and output.* Speech processing skills are thought to form an integrated system (Rees, 2001). As presented in section 2.4.1., difficulties with speech perception have been identified in children with speech sound disorders (Edwards, 2002; Rvachew & Grawburg, 2006). It is hypothesized that intact speech perception skills are a prerequisite for the development of speech production skills. Therefore it will be investigated if there is a relationship between input and output processing, both synchronically and diachronically, in typically developing children.

3. *The relationship between speech processing and language development*. Auditory discrimination skills have been found to correlate with later language development (Tsao, Liu, & Kuhl, 2004) and vocabulary (Edwards, 2002). Research data suggest that poor speech perception may explain poor word production (Ziegler, et al., 2011). In line with these findings is the suggestion that phonological processing correlates with language development (Chiat, 2001). Therefore it will be investigated if there is a relationship between speech processing, in particular input processing and language development within and across time.
4. *The relationships between vocabulary development, accuracy of stored phonological representations and phonological awareness*. The role of vocabulary is thought to be crucial in the development of accurate phonological representations and phonological awareness. It has been suggested that early lexical representations are holistic in nature and gradually become more accurate as a result of vocabulary growth (Metsala & Walley, 1998). According to the lexical restructuring model vocabulary growth leads to the formation of more accurate representations; restructuring is a prerequisite for the development of explicit segmentation or phonological awareness skills. Furthermore, difficulties with vocabulary comprehension (Crosbie, Dodd, & Howard, 2002) and vocabulary production (Constable, Stackhouse, & Wells, 1997) have been attributed to imprecise phonological representations, rather than to difficulties with semantic knowledge. Therefore it will be investigated if there is a relationship between vocabulary development, accuracy of stored phonological representations and phonological awareness.
5. *The relationships between vocabulary development, language development and phonological awareness in a morphologically rich language*. Chrysochoou & Bablekou (2011) provide evidence that vocabulary knowledge can partially account for oral comprehension for Greek speaking preschool age children. Ziegler & Goswami (2005) suggest that properties of the oral language such as a highly inflectional morphological system can affect the development of segmentation abilities. Therefore it will be investigated if there is a relationship between language development, vocabulary production and phonological awareness skills.
6. *The relationships between short term memory (STM), language and speech processing*. STM is thought to influence vocabulary development (Gathercole & Baddeley, 1989), language comprehension (Florit, Roch, Altoe, & Levorato, 2009),

language production (Adams & Gathercole, 1995, 2000) and syntax (Blake, Mysczyszyn & Jokel, 2004). Therefore, it will be investigated if there is a relationship between STM and vocabulary production, language comprehension, language production and auditory discrimination.

7. *The relationship of processing of polysyllabic items to short term memory, integrity of phonological representations, segmentation abilities and vocabulary*. Polysyllabic words, which have been found to be sensitive in identifying difficulties with phonological processing (James, et al., 2008), are frequent in the Greek language. Word length has been found to relate to STM skills (Gathercole, 2006). Accuracy of polysyllabic word production has been related to the accuracy of stored phonological representations (Vance, 2004) and segmentation abilities (Snowling, 1981). Therefore, it will be investigated if there is a relationship between the accuracy of polysyllabic word production and the ability to recall words, the accuracy of stored phonological representations and segmentation skills.

5.1 Factors affecting performance on speech processing tasks

5.1.1 Linguistic domain effect

In order to explore the development of morphological elements as part of the developing speech processing system, the first question to address is whether linguistic domain, i.e. phonology or morphology, affects performance. It is investigated whether comparable speech processing skills are involved in input processing of both phonological and morphological characteristics of spoken language. Therefore performance was compared in tasks that tap the same level of processing for stimuli from these different linguistic domains. The developmental pattern is expected to be similar both for phonological and morphological stimuli over time.

It is hypothesized that:

i. There will not be a significant difference in real word auditory discrimination performance between phonological and morphological items within each age group between testing points.

ii. There will not be a significant difference in real word repetition performance between phonological and morphological items within each age group between testing points.

5.1.1.1 Phonology vs. morphology in real word auditory discrimination

In order to investigate if there is an effect of linguistic domain on auditory discrimination, responses to items of phonological interest (RWAudDPhon presented in Table 4-12) and items of morphological interest (RWAudDMor presented in Table 4-13) were compared. A 3 (Time: T1, T2, T3) by 2 (Domain: Phonological, Morphological) Repeated Measures ANOVA was performed with age group (Group 1, Group 2) as the between group factor with Bonferroni adjustment for multiple comparisons. The analyses showed a main effect of time both for Group 1 ($F_{(2,13)}$ =29.95, p<.001) and Group 2 ($F_{(2,16)}$=16.70, p<.001) . There was not a main effect of linguistic domain for Group 1 ($F_{(1,14)}$=1.84, p=.197) or for Group 2 ($F_{(1,17)}$ =1.73, p=.205). The main effect of time arose because children could successfully discriminate more items over time. Inspection of the means indicates that children scored higher on RWAudDMor than on RWAudDPhon, however, there was not a significant effect of morphology and the pattern of development was similar for both domains. Performance of the two groups across time can be seen in Figure 5-1.

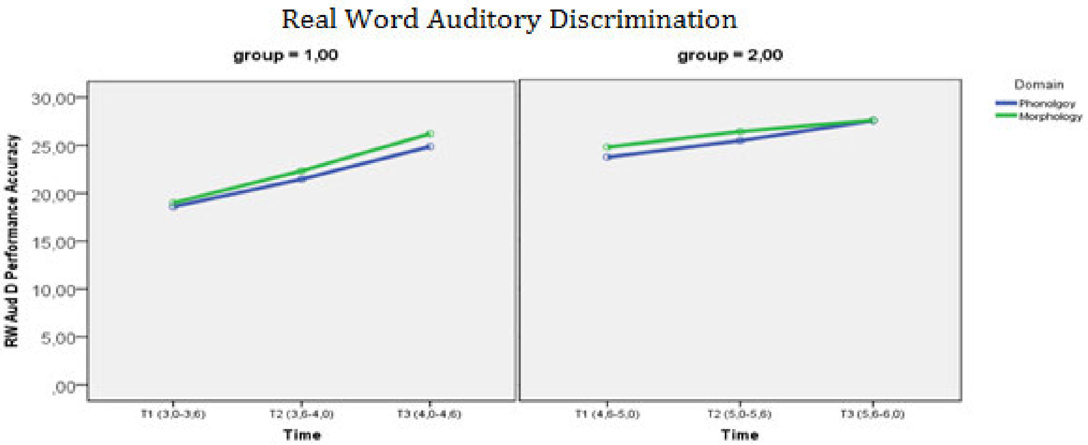

Figure 5-1 Real Word Auditory Discrimination for items of phonological and morphological interest across time points

5.1.1.2 Phonology vs. morphology in real word repetition

5.1.1.2.1 a) Whole word accuracy

In order to investigate if there is an effect of linguistic domain on real word repetition scored on a whole word basis, production of items of phonological interest (RWRepPhonWW as presented in Table 4-18) and items of morphological interest (RWRepMorWW as presented in Table 4-19) were compared. A 3 (Time: T1, T2, T3) by 2 (Domain: Phonological, Morphological) Repeated Measures ANOVA was performed with age group (Group 1, Group 2) as the between groups factor with Bonferroni adjustment for multiple comparisons. The analyses showed a main effect of time both for Group 1 ($F_{(2,13)}$ =15.74, p<.001) and Group 2 ($F_{(2,16)}$=4.62, p=.026). The main effect of time arose because children could repeat more words accurately over time. There was not a main effect of linguistic domain for Group 1 ($F_{(1,14)}$=1,28, p=.419), however for Group 2 there was a just significant linguistic domain effect in favour of Phonological items ($F_{(1,17)}$=4,60, p=.047). There was not a time by domain interaction for either group. Performance of the two groups across time can be seen in Figure 5-2.

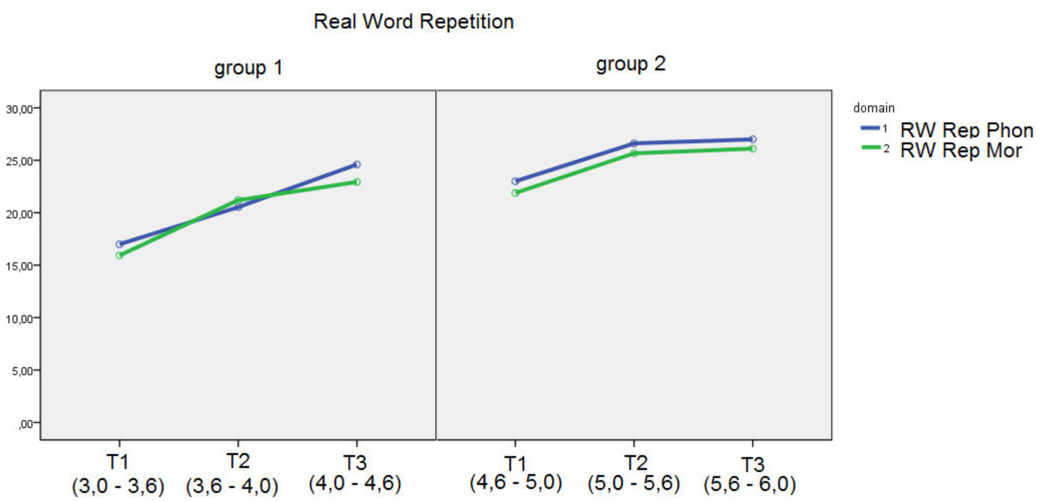

Figure 5-2 Real Word repetition for items of phonological and morphological interest across time points

In order to investigate why such a main effect of domain arose for Group 2, paired-samples t-tests were performed (see Table 5-1). Comparison of performance was made between RWRepPhon and RWRepMor at each assessment point.

Table 5-1 Paired samples comparison of performance between RWRep tasks for Group 2

		t	Df	Sig. (2-tailed)
Pair 1	T1RWRepPhon-RWRepMor	-.24	21	.816
Pair 2	T2RWRepPhon-RWRepMor	1.12	18	.279
Pair 3	T3RWRepPhon-RWRepMor	1.13	17	.275

Comparison of means did not indicate a statistically significant difference between the two tasks at any of the assessment points. As Paired Samples t-tests reveal no statistically significant difference in performance accuracy between the two tasks and the developmental pattern of the two was similar, the main effect of linguistic domain in RWRep of Group 2 should be treated with caution.

5.1.1.2.2 b) Percentage Consonants correct

Subsequently, performance scored for Percentage of Consonants Correct (PCC), which is considered to be a more sensitive measure than whole word scoring, was compared for items of phonological interest (RWRepPhonPCC as presented in Table 4-21) and items of morphological interest (RWRepMorPCC as presented in Table 4-22). A 3 (Time: T1, T2, T3) by 2 (Domain: Phonological, Morphological) Repeated Measures ANOVA, was performed with age group (Group 1, Group 2) as the between group factor with Bonferroni adjustment for multiple comparisons. The analyses showed a main effect of time both for Group 1 ($F_{(2, 13)}$=11.07, p<.002) and Group 2 ($F_{(2, 16)}$=6.53, p=.008). For Group 1 there was a main effect of linguistic domain ($F_{(1,14)}$=8.01, p=.013), and a significant interaction between time and domain ($F_{(2,13)}$=5.35, p=.020). For Group 2 group the main effect of linguistic domain missed significance ($F_{(1,17)}$=3.91, p=.064), however there was a significant time by domain interaction ($F_{(2,16)}$=6.79, p=.007). Performance of the two groups across time can be seen in Figure 5-3.

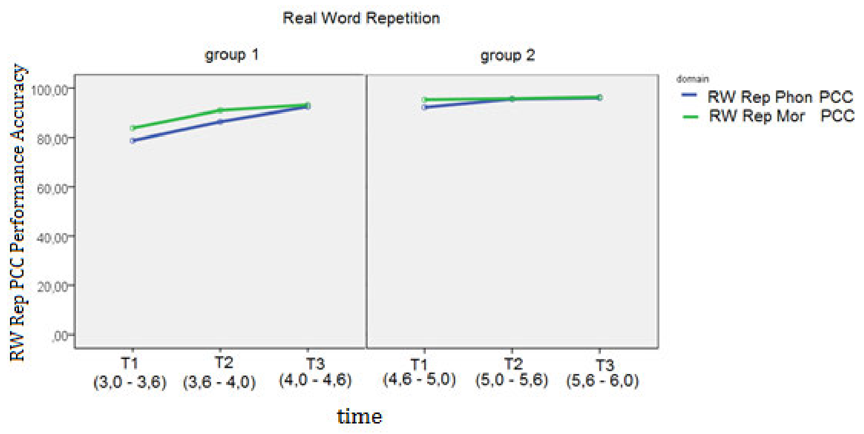

Figure 5-3 RW Rep PCC for items of phonological and morphological interest across time points

In order to investigate why such a main effect of domain arose for Group 1 and the nature of interaction between time and domain for both groups, follow–up paired–samples t–tests were performed. Comparison of performance was made between RWRepPhonPCC and RWRepMorPCC at each assessment point. As shown in Table 5-2 for Group 1 performance on RWRepPhonPCC was significantly lower than performance on RWRepMorPCC at T1 ($t_{(15)}$=-2.59, p=.021) and at T2 ($t_{(15)}$=-2.80, p=.014). However, this domain effect on performance was not evident at T3. The developmental pattern was similar both for RWRepPhonPCC and RWRepMorPCC as indicated by significant improvement in performance occurring from one assessment point to another (section 4.2.6). Although performance in both tasks improves significantly over time, performance on RWRepPhonPCC does not reach the same level of accuracy as performance on RWRepMorPCC at T1 and T2, giving rise to an interaction between time and domain.

Table 5-2 Paired samples comparison of performance between RWRep PCC tasks for linguistic domain Group 1

	t	df	Sig. (2-tailed)
T1RWRepPhonPCC–T1RWRepMorPCC	-2.59	15	.021
T2RWRepPhonPCC-T2RWRepMorPCC	-2.80	15	. 014
T3RWRepPhonPCC-T3RWRepMorPCC	-.63	14	.540

Follow-up paired – samples t-tests (Table 5-3) indicated that for Group 2 performance on RWRepPhonPCC was significantly lower than performance on RWRepMorPCC at T1 ($t_{(20)}$= -4.23, p<.001), however this difference was not evident at the later time points. Inspection of the means indicates that performance on RWRepPhonPCC and RWRepMorPCC improves over time, however a significant difference in performance was only identified in development of RWRepPhonPCC from T1 to T2 (section 4.2.6), giving rise to an interaction between time and domain.

Table 5-3 Paired samples comparison of performance between RWRep PCC tasks for linguistic domain Group 2

	t	df	Sig. (2-tailed)
T1RWRepPhonPCC–T1RWRepMorPCC	-4.23	20	.000
T2RWRepPhonPCC-T2RWRepMorPCC	-.29	18	.772
T3RWRepPhonPCC-T3RWRepMorPCC	-.61	17	.553

5.1.1.3 Summary

In summary, the main effect of linguistic domain was evident across some but not all levels of the condition of the other independent variable i.e. the three time points for both groups.

Moreover, there was a discrepancy between the two scoring methods. Whole word scoring did not indicate an effect of linguistic domain in real word repetition for group 1. A just significant linguistic domain effect in favour of phonological items was found for group 2 when whole word scoring was used, however comparison of means did not indicate a statistically significant difference between phonological and morphological items at any of the assessment points. PCC scoring indicated a linguistic domain effect in favour of morphological items for group 1 and an interaction between time and domain for both groups. Indications for the existence of a main effect of linguistic domain in real word repetition are contradictory. Statistical analysis has not demonstrated beyond doubt that there is an effect of either domain. Findings are discussed in chapter 7.

5.1.2 Word length effect

Word length is known to affect performance accuracy of English speaking children in output tasks (James et al., 2008; Gathercole et al., 1991). In Greek language polysyllabic words are frequently used, therefore it is important to investigate the potential effect of word length on speech production and how it may affect performance over the course of development of the speech processing system. In order to investigate whether specific characteristics of words that belong in the same category have an effect on performance during repetition, a comparison was made between items of 2-3 syllables and polysyllabic items, i.e. words of more than three syllables. Given the nature of the Greek language, test items in both conditions i.e. words of 2-3 syllables (RWRepPhon) and polysyllabic words (RWRepPol) have morphological characteristics. However all the items included in the tasks were nouns, in the nominative case of singular and the only grammatical morpheme contained was the suffix, therefore it is considered that direct comparison can be made for differences in word length, without taking into account the morphological features. There were 30 words of 2-3 syllables included in RWRepPhon task and 21 polysyllabic words (4 -5 syllables) included in the RWRepPol task. Because of the unequal sample sizes performance was compared on the basis of scoring for the percentage of consonants correct. It is hypothesized that:

i. There will be a significant difference in real word repetition performance between words of standard length and polysyllabic words within each age group between testing points. Performance on words of 2-3 syllables (RWRepPhon) will be better than performance on polysyllabic words (RWRepPol).
ii. There will be a significant difference in nonword repetition performance between nonwords of 2-3 syllables and polysyllabic nonwords within each age group between testing points. Performance on 2-3 syllable nonwords (NWRepPhon) will be better than performance on polysyllabic nonwords (NWRepPol).

5.1.2.1 Word length effect on real word repetition

In order to investigate if there is a word length effect on real word repetition as tested on Real Word Repetition (RWRep) production of words of 2-3 syllables (RWRepPhonPCC as presented in Table 4-21) and polysyllabic words (RWRepPolPCC as presented in Table 4-23) were compared. A 3 (Time: T1, T2, T3) by 2 (Length: 2-3 syllables, Polysyllabic) Repeated Measures ANOVA, was performed with age group (Group 1, Group 2) as the between group factor with Bonferroni adjustment for multiple comparisons. The analyses showed a main effect of time both for Group 1 ($F_{(2,13)}$ =14.47, p<.001) and Group 2 ($F_{(2,14)}$=5.25, p=.020). The main effect of time arose because repetition accuracy increased over time. Performance of the two groups across time can be seen in Figure 5-4.

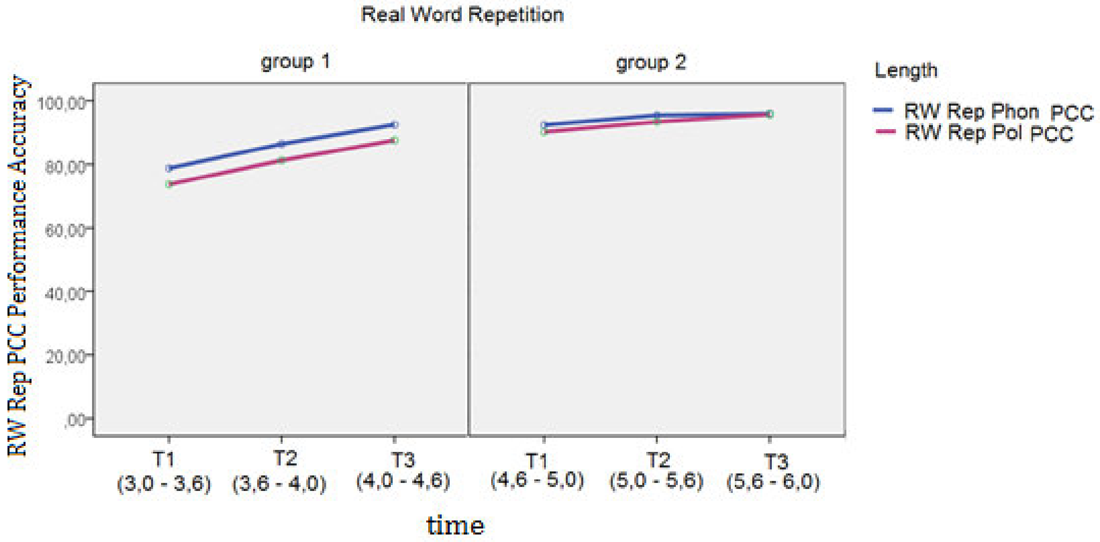

Figure 5-4 RW Rep PCC for items of standard length and polysyllabic items across time points

For Group 1 analysis indicated a main effect of word length ($F_{(1,14)}$=13.38, p=.003). Follow up paired samples t-tests (Table 5-4) indicate that Group 1 scored significantly higher on RWRepPhon than on RWRepPol across time points, indicating a word length effect. There was not a significant time by word length interaction ($F_{(2,13)}$=.011, p=.898), as performance accuracy increased significantly for both tasks between time points.

Table 5-4 Paired samples comparison of performance between RWRep PCC tasks for word length for Group 1

	t	df	Sig. (2-tailed)
T1RWRepPhonPCC–T1RWRepPolPCC	3.79	15	.002
T2RWRepPhonPCC-T2RWRepPolPCC	2.25	15	.040
T3RWRepPhonPCC-T3RWRepPolPCC	3.52	15	.003

For Group 2 Repeated Measures Anova did not yield a significant word length effect ($F_{(1,15)}$=2.12, p=.166), nor a significant interaction between time and word length ($F_{(2,14)}$=3.55, p=.057). Inspection of the means indicates that children repeated words of 2 and 3 syllables better than words of 4 and 5 syllables. Paired–samples t-tests (Table 5-5) were performed to compare performance between RWRepPhonPCC and RWRepPolPCC at each assessment point. Analysis indicates that performance of Group 2 was significantly better on RWRepPhonPCC than performance on RWRepPolPCC at T1 ($t_{(18)}$=2.26, p=.037) and at T2 ($t_{(18)}$=2.68, p=.015) but not at T3. These differences, only evident at two of the three time points, were not sufficient to result in an overall word length effect for Group 2.

Table 5-5 Paired samples comparison of performance between RWRep PCC tasks for word length for Group 2

	t	df	Sig. (2-tailed)
T1RWRepPhonPCC–T1RWRepPolPCC	2.26	18	.037
T2RWRepPhonPCC-T2RWRepPolPCC	2.68	18	.015
T3RWRepPhonPCC-T3RWRepPolPCC	.28	17	.780

In summary, Group 1 repeated 2 – 3 syllable words significantly better than 4 – 5 syllable words across all time points. Group 2 repeated 2 – 3 syllable words significantly better than 4 – 5 syllable words at T1 and T2.

5.1.2.2 Word length effect on Nonword Repetition

In order to investigate if there is a word length effect on nonword repetition as tested on NonWord Repetition (NWRep) production of nonwords of 2-3 syllables (NWRepPhonPCC as presented in Table 4-27) and polysyllabic nonwords (NWRepPolPCC as presented in Table 4-29) were compared. A 3 (Time: T1, T2, T3) by 2 (Length: 2-3 syllables, Polysyllabic) Repeated Measures ANOVA, was performed with age group (Group 1, Group 2) as the between group factor with Bonferroni adjustment for multiple comparisons. The analyses showed a main effect of time both for Group 1 ($F_{(2,13)}$=19.92, p<.001) and Group 2 ($F_{(2,16)}$=8.14, p=.004). The main effect of time arose because repetition accuracy increased over time. Performance of the two groups can be seen in Figure 5-5.

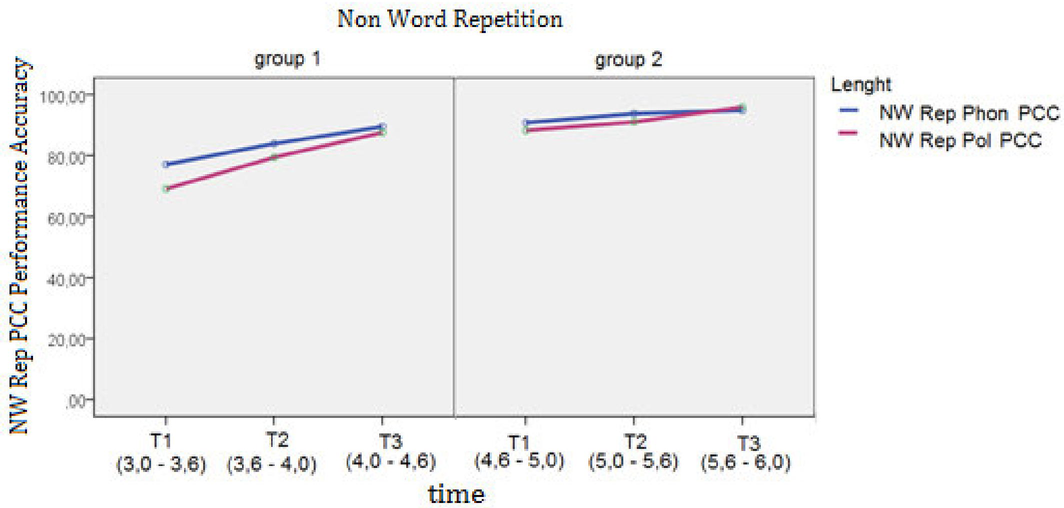

Figure 5-5 NW Rep PCC for items of standard length and polysyllabic items across time points

For Group 1 analysis indicated a main effect of stimulus length ($F_{(1,14)}$=25.61, p<.001). Follow up paired samples t-tests (Table 5-6) indicate that Group 1 scored significantly higher on NWRepPhonPCC than on NWRepPolPCC at all three time points. There was a significant time by nonword length interaction ($F_{(2,13)=.}$12.74, p=.001), as performance accuracy increased significantly for both tasks between time points (section 4.2.7), but the difference in performance between the two was less significant over time.

Table 5-6 Paired samples comparison of performance between NWRep PCC for word length for Group 1

	t	df	Sig. (2-tailed)
T1NWRepPhonPCC–T1NWRepPolPCC	5.37	15	.000
T2NWRepPhonPCC-T2NWRepPolPCC	4.19	15	.001
T3NWRepPhonPCC-T3NWRepPolPCC	2.31	14	.036

For Group 2 analysis did not indicate a main effect of stimulus length ($F(_{1,17})$=1.79, p=.169) however, there was an interaction between time and stimulus length ($F(_{2,16})$=7.49, p=.005). Follow up paired-samples t-tests (Table 5-7) indicate that performance of Group 2 was significantly better on NWRepPhonPCC than performance on NWRepPolPCC at T1 ($t(_{20})$=2.59, p=.018) and at T2 ($t(_{18})$=2.27, p=.036) but not at T3. Time significantly affects performance on nonword repetition only for polysyllabic items and not for items of 2-3 syllables (section 4.2.7), thus establishing a time by length interaction.

Table 5-7 Paired samples comparison of performance between NWRep PCC for word length for Group 2

	t	df	Sig. (2-tailed)
T1NWRepPhonPCC–T1NWRepPolPCC	2.59	20	.018
T2NWRepPhonPCC-T2NWRepPolPCC	2.27	18	.036
T3NWRepPhonPCC-T3NWRepPolPCC	.70	17	.494

In summary, Group 1 repeated 2 – 3 syllable nonwords significantly better than 4 – 5 syllable nonwords across all time points; however difference in performance between the two tasks became less significant over time. Group 2 repeated 2 – 3 syllable nonwords significantly better than 4 – 5 syllable nonwords at T1 and T2.

5.1.2.3 Summary

To summarise the findings on word length across both word types, a word length effect was evident for Group 1 both for Real Words and Nonwords. Group 2 performed better on 2 – 3 syllable items in comparison to 4 – 5 syllable items but this difference in performance was significant only at T1 and T2. Factor analysis largely supports the hypothesis that word length affects performance accuracy.

5.1.3 Lexicality effect

Analysis of the data in Chapter 4 indicated that children scored higher when they were asked to process real words as opposed to nonwords. Stored linguistic knowledge may have a beneficial effect for English speaking children (Vance, Stackhouse, & Wells, 2005). The next question to address is whether existing linguistic knowledge affects performance. It is explored whether stored representations may support lower level processing for phonological and morphological elements of speech. It is also investigated whether the magnitude of this potential effect changes as a result of development. Therefore performance was compared in tasks that tap different levels of processing for stimuli that otherwise share the same properties i.e. processing of Real Words (RWRep) vs. Nonwords (NWRep). RW processing enables top – down processing i.e. it is possible for a child to access and use previously stored information whereas NW processing requires bottom – up processing i.e. there is no prior knowledge to support performance. As previously described in 2.4.3, significant differences have been observed between performance accuracy on RW and NW tasks (Vance et al., 2005). Thus superior performance in RW tasks is predicted.

Specifically, it is hypothesized that:

i. There will be a significant difference between performance in Real Word Auditory Discrimination (RWAudD) and Nonword Auditory Discrimination (NWAudD) performance for items of phonological interest within each age group between testing points.

ii. There will be a significant difference between performance in Real Word Auditory Discrimination (RWAudD) and Nonword Auditory Discrimination (NWAudD) performance for items of morphological interest within each age group between testing points.

iii. There will be a significant difference between performance in Real Word Repetition (RWRep) and Nonword Repetition (NWRep) performance for items of phonological interest within each age group between testing points.

iv. There will be a significant difference between performance in Real Word Repetition (RWRep) and Nonword Repetition (NWRep) performance for items of morphological interest within each age group between testing points.

v. There will be a significant difference between performance in Real Word Repetition (RWRep) and Nonword Repetition (NWRep) performance for polysyllabic items (4 – 5 syllables) within each age group between testing points.

5.1.3.1 Lexicality effect in Auditory Discrimination of items of Phonological Interest

In order to investigate if there is a lexicality effect on Auditory Discrimination of phonologically different items as tested on Real Word Auditory Discrimination (RWAudD) and Nonword Auditory Discrimination (NWAudD) of items of phonological interest (Phon) responses to RWAudDPhon (as presented in Table 4-12) and NWAudDPhon (as presented in Table 4-10) were compared. A 3 (Time: T1, T2, T3) by 2 (Lexicality: Words, Nonwords) Repeated Measures ANOVA, was performed with age group (Group 1, Group 2) as the between group factor with Bonferroni adjustment for multiple comparisons. Analyses yielded a main effect of time for Group 1 ($F_{(2,13)}$=20.07, p<.001) and Group 2 ($F_{(2,16)}$=25.40, p=.189). The main effect of time arose because performance accuracy improved over time.

For Group 1 there was a main effect of Lexicality ($F_{(1,14)}$=6.90, p=.020). Children scored higher when processing RW as compared to NW. For Group 2 Repeated measures ANOVA did not yield a Lexicality effect ($F_{(1,17)=}$2.12, p=.163) nor an interaction between time and Lexicality ($F_{(2,16)}$=1.85, p=.189). Performance of the two groups can be seen in Figure 5-6.

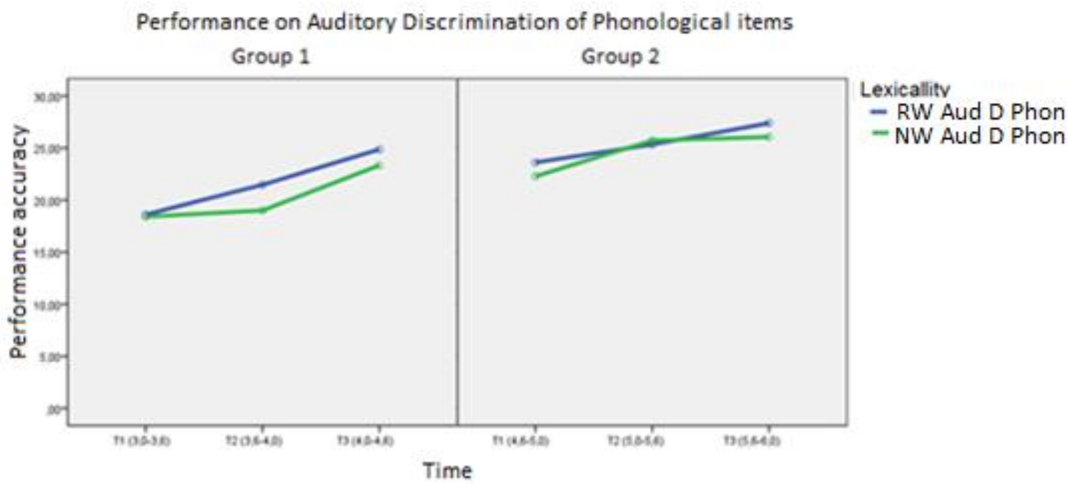

Figure 5-6 Auditory Discrimination of RW and NW Phonological items across time points

5.1.3.2 Lexicality effect in Auditory Discrimination of items of Morphological Interest

In order to investigate if there is a lexicality effect on Auditory Discrimination of morphologically different items as tested on Real Word Auditory Discrimination (RWAudD) and Nonword Auditory Discrimination (NWAudD) of items of morphological interest (Mor) responses to RWAudDMor (presented in Table 4-13) and NWAudDMor (presented in Table 4-11) were compared. A 3 (Time: T1, T2, T3) by 2 (Lexicality: Words, Nonwords) Repeated Measures ANOVA, was performed with age group (Group 1, Group 2) as the between group factor with Bonferroni adjustment for multiple comparisons. Analyses yielded a main effect of time both for Group 1 ($F_{(2,14)}$=30.8, p<.001) and Group 2 ($F_{(2,16)}$=7.12, p=.006). There was neither a Lexicality effect nor a time by Lexicality interaction for any of Groups. The main effect of time arose because performance improved from one assessment point to the next, but there were not substantial differences in performance between the two tasks and developmental pattern was similar over time. Performance of the two groups over time can be seen in Figure 5-7.

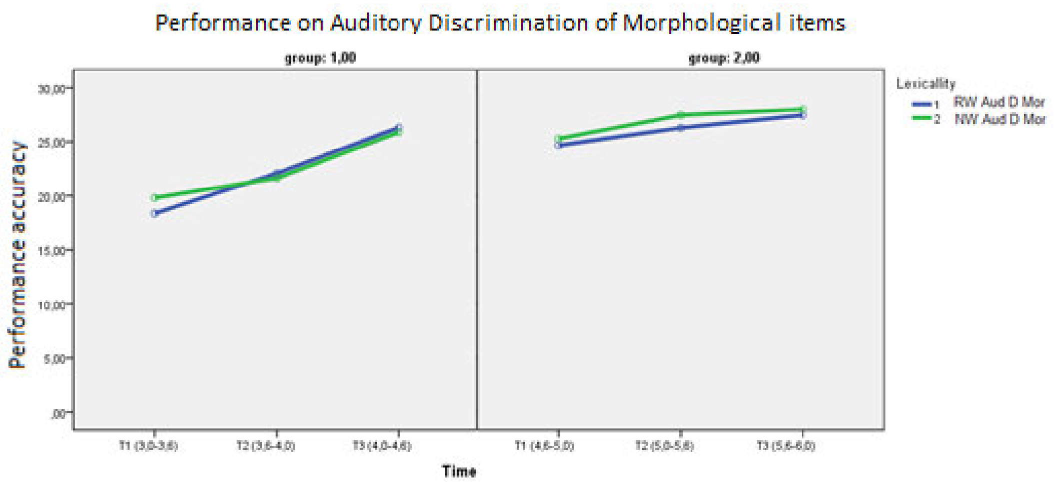

Figure 5-7 Auditory Discrimination of RW and NW Morphological items across time points

In summary, lexicality in input tasks only had an effect in performance of Group 1 in discriminating between items with different phonological characteristics. Children scored higher on real word than on nonword auditory discrimination of phonological items. For auditory discrimination of morphological items, there was no statistically significant difference in performance between real words and nonwords for any of the groups. Results provide support on the hypothesis for lexicality effect in auditory discrimination of phonological stimuli for group 1.

5.1.3.3 Lexicality effect in repetition of items of Phonological Interest

5.1.3.3.1 a) Whole Word scoring

In order to investigate if there is a lexicality effect on Repetition of phonologically different items as tested on Real Word Repetition (RWRep) and Nonword Repetition (NWRep) of items of phonological interest (Phon) responses to RWRepPhonWW (presented in Table 4-18) and NWRepPhonWW (presented in Table 4-24) were compared. A 3 (Time: T1, T2, T3) by 2 (Lexicality: Words, Nonwords) Repeated Measures ANOVA, was performed with age group (Group 1, Group 2) as the between group factor with Bonferroni adjustment for multiple comparisons, taking the number of items correctly repeated for items of phonological interest as the dependent variable.

Analysis yielded a main effect of time for Group 1 ($F_{(2,13)}$=15.55, p<.001). For Group 2 the main effect of time just missed significance ($F_{(2,14)}$=3.49, p=.059). Analysis also yielded a main effect of Lexicality for both groups i.e. Group 1 ($F_{(1,14)}$=9.60, p=.008) and Group 2 ($F_{(1,15)}$=13.06, p=.003).

The main effect of time arose for Group 1 because performance improved from one assessment time to the next. The main effect of Lexicality arose for both groups because children performed better on real word repetition than nonword repetition for items of phonological interest. There was not an interaction between time and Lexicality, i.e. the magnitude of Lexicality effect did not change over time. Performance of the two groups across time can be seen in Figure 5-8.

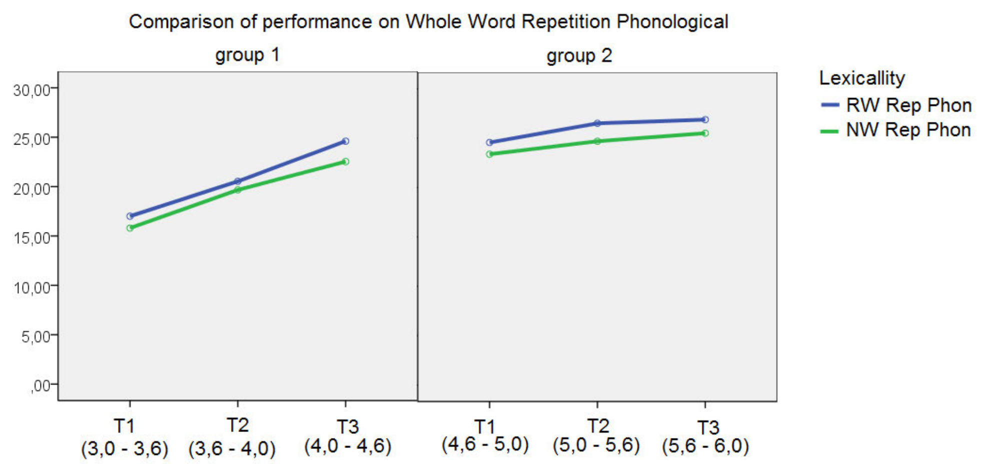

Figure 5-8 Repetition of RW and NW Phonological items scored for whole word accuracy across time points

5.1.3.3.2 b) Percentage Consonants Correct

A 3 (Time: T1, T2, T3) by 2 (Lexicality: Words, Nonwords) Repeated Measures ANOVA, was performed with age group (Group 1, Group 2) as the between group factor with Bonferroni adjustment for multiple comparisons, taking percentage consonants correct on repetition tasks for items of phonological interest scored for the PCC as the dependent variable.

Analysis yielded a main effect of time both for Group 1 ($F_{(2,13)}$=11,35, p<.001) and Group 2 ($F_{(2,16)}$=7,32, p=.006). Analysis also yielded a main effect of Lexicality for both groups i.e. Group 1 ($F_{(1,14)}$=14.45, p=.002) and Group 2 ($F_{(1,17)}$=12.23, p=.003). There was not a time by Lexicality interaction for either of the Groups. The main effect of time arose because performance improved from one assessment time to the next. The main effect of Lexicality arose because children performed better on real word repetition than nonword repetition for items of phonological interest scored for PCC. There was not an interaction between time and Lexicality, i.e. the magnitude of Lexicality effect did not change over time. Performance of the two groups across time can be seen in Figure 5-9.

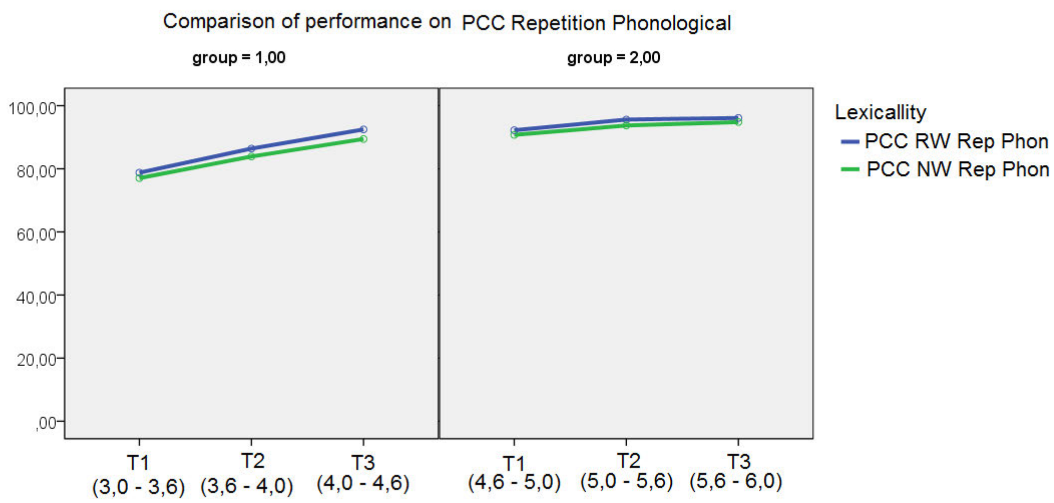

Figure 5-9 Repetition of RW and NW Phonological items scored for PCC accuracy across time points

5.1.3.4 Lexicality effect in repetition of items of Morphological Interest

5.1.3.4.1 a) Whole Word scoring

In order to investigate if there is a lexicality effect on Repetition of morphologically different items as tested on Real Word Repetition (RWRep) and Nonword Repetition (NWRep) of items of morphological interest (Mor) responses to RWRepMorWW (as presented in Table 4-19) and NWRepMorWW (as presented in Table 4-25) were compared. A 3 (Time: T1, T2, T3) by 2 (Lexicality: Words, Nonwords) Repeated Measures ANOVA, was performed with age group (Group 1, Group 2) as the between group factor with Bonferroni adjustment for multiple comparisons, taking the number of items correctly repeated for items of morphological interest as the dependent variable.

Analysis yielded a main effect of time for Group 1 ($F_{(2,13)}$=14.61, p<.001) and a main effect of Lexicality both for Group 1 ($F_{(1,14)}$=11.46, p=.004) and Group 2 ($F_{(1,15)}$=7.73, p=.014). There was not an interaction between time and Lexicality for any of the Groups.

The main effect of time arose for Group 1 because there was a significant improvement of performance in both tasks over time. The main effect of Lexicality arose for both groups because children performed significantly better on RWRepMorWW than on NWRepMorWW across time points. The magnitude of Lexicality effect did not change over time. Performance of the two groups can be seen in Figure 5-10.

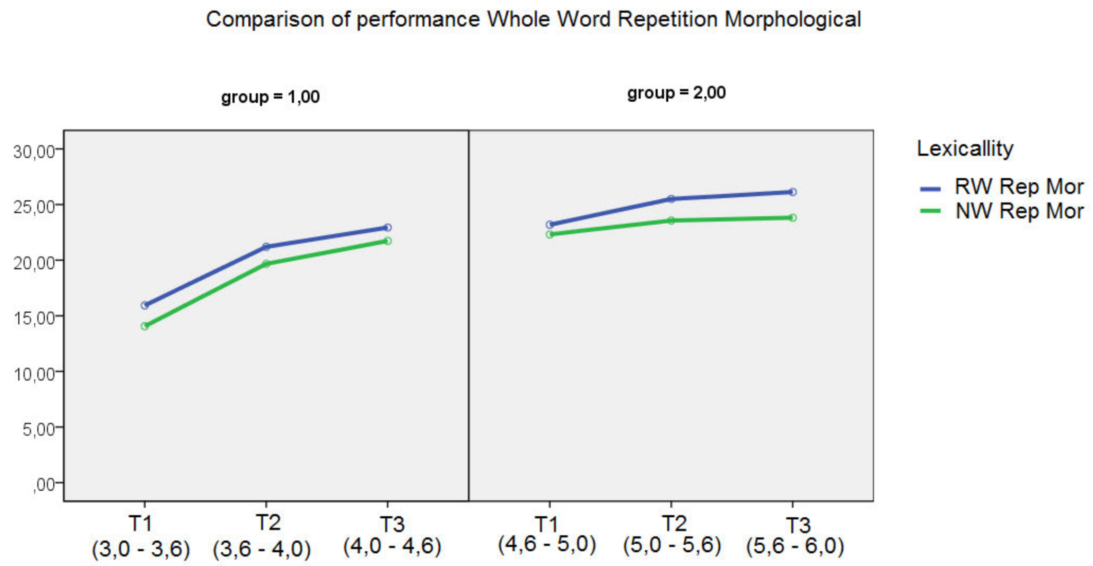

Figure 5-10 Repetition of RW and NW Morphological items scored for whole word accuracy across time

5.1.3.4.2 b) Percentage Consonants Correct

A 3 (Time: T1, T2, T3) by 2 (Lexicality: Words, Nonwords) Repeated Measures ANOVA, was performed with age group (Group 1, Group 2) as the between group factor with Bonferroni adjustment for multiple comparisons, taking percentage consonants correct on repetition tasks for items of morphological interest scored for the PCC as the dependent variable.

Analysis yielded a main effect of time both for Group 1 ($F_{(2,13)}$=12.27, p<.001) and Group 2 ($F_{(2,14)}$=4.13, p=.039). Analysis also yielded a main effect of Lexicality for both groups i.e. Group 1 ($F_{(1,14)}$=52.29, p=.001) as well as Group 2 ($F_{(1,15)}$=22.38, p=.001). There was not a time by Lexicality interaction for any of Groups. The main effect of time arose because performance improved from one assessment time to the next. The main effect of Lexicality arose because children performed better on real word repetition than nonword repetition for items of morphological interest scored for PCC. There was not an interaction between time and Lexicality, i.e. the magnitude of Lexicality effect did not change over time. Performance of the two groups across time can be seen in Figure 5-11.

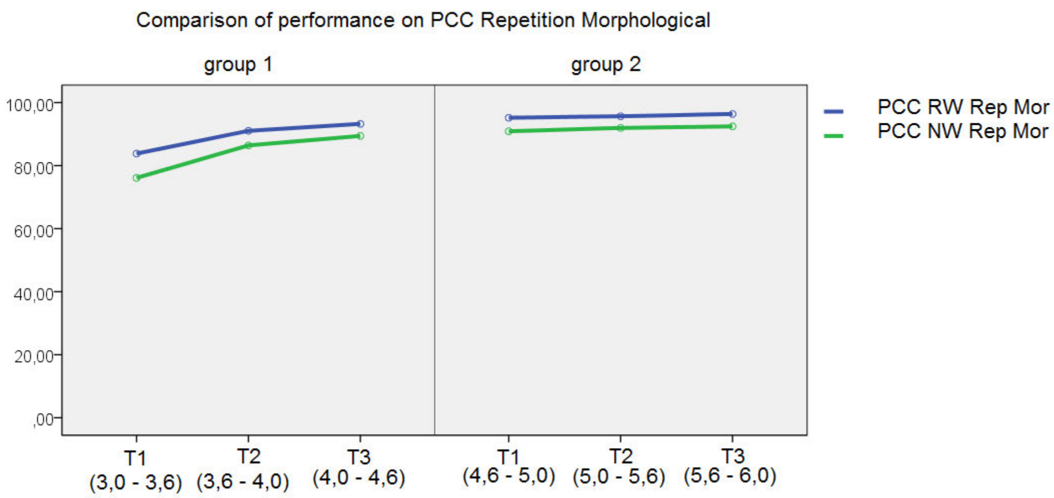

Figure 5-11 Repetition of RW and NW Morphological items scored for PCC across time

5.1.3.5 Lexicality effect in repetition of polysyllabic items

5.1.3.5.1 a) Whole Word scoring

In order to investigate if there is a lexicality effect on Repetition of polysyllabic items as tested on Real Word Repetition (RWRep) and Nonword Repetition (NWRep) of polysyllabic items (Pol) responses to RWRepPolWW (as presented in Table 4-20) and NWRepPolWW (as presented in Table 4-29) were compared. A 3 (Time: T1, T2, T3) by 2 (Lexicality: Words, Nonwords) Repeated Measures ANOVA, was performed with age group (Group 1, Group 2) as the between group factor with Bonferroni adjustment for multiple comparisons, taking the number of polysyllabic items correctly repeated as the dependent variable.

Analysis yielded a main effect of time for Group 1 ($F_{(2,13)}$=15.10, p<.001) and a main effect of Lexicality both for Group 1 ($F_{(1,14)}$=21.51, p=.003) and Group 2 ($F_{(1,15)}$=34.23, p<.001). There was an interaction between time and Lexicality for Group 2 ($F_{(2,14)}$=.490, p=.024).

In order to investigate the nature of interaction between time and Lexicality for group 2, follow-up paired-samples t-tests were performed (Table 5-8). Comparison of performance was made between RWRepPolWW and NWRepPolWW at each assessment point.

Table 5-8 Paired samples comparison of performance in Polysyllabic items between real words and nonwords for group 2

	t	df	Sig. (2-tailed)
T1RWPolWW–T1NWPolWW	1.43	19	.169
T2RWPolWW-T2NWPolWW	5.18	18	.000
T3RWPolWW-T3NWPolWW	3.90	17	.001

The main effect of time arose for Group 1 because there was a significant improvement of performance in both tasks over time. The main effect of Lexicality arose because children performed significantly better on RWRepPol than on NWRepPol across time points.

The main effect of time arose for Group 2, because performance in both tasks improved significantly over time. The main effect of Lexicality arose because children at T2 and T3 repeated real words significantly better than nonwords. The interaction between time and Lexicality arose because Lexicality did not affect performance at all time points. Performance of the two groups can be seen in Figure 5-12.

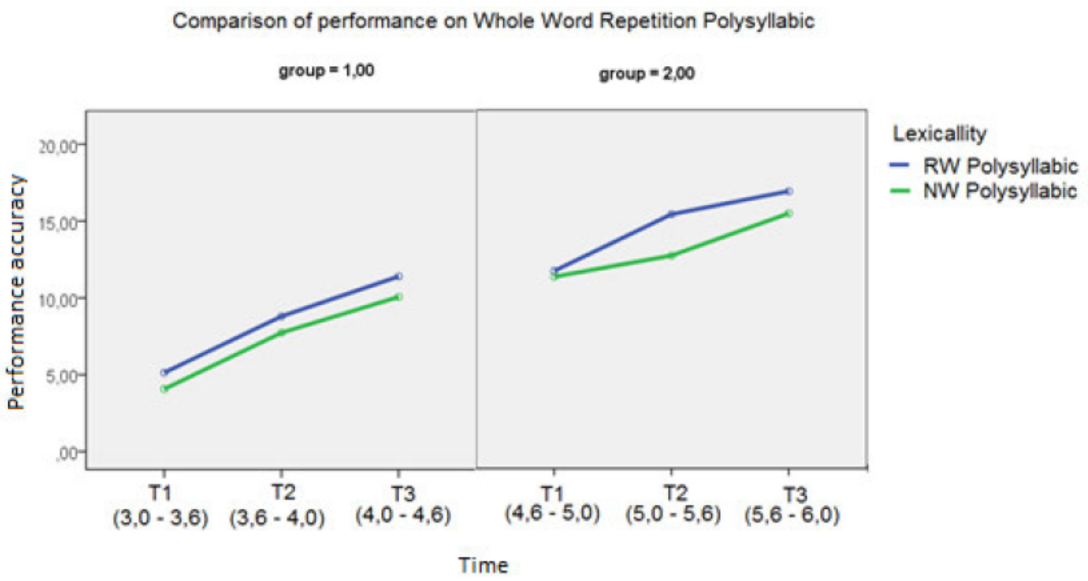

Figure 5-12 Repetition of RW and NW Polysyllabic items scored for whole word accuracy across time

5.1.3.5.2 b) Percentage Consonants Correct

A 3 (Time: T1, T2, T3) by 2 (Lexicality: Words, Nonwords) Repeated Measures ANOVA, was performed with age group (Group 1, Group 2) as the between group factor with Bonferroni adjustment for multiple comparisons, taking percentage consonants correct on repetition tasks for polysyllabic items scored for PCC as the dependent variable.

Analysis yielded a main effect of time both for Group 1 ($F_{(2,13)}$=23.45, p<.001) and Group 2 ($F_{(2,14)}$=5.80, p=.015). Analysis also yielded a main effect of Lexicality for both groups i.e. Group 1 ($F_{(1,14)}$=13.60, p=.002) as well as Group 2 ($F_{(1,15)}$=37.30, p<.001). There was not a time by Lexicality interaction for either of the groups. The main effect of time arose because performance improved from one assessment time to the next. The main effect of Lexicality arose because children performed better on real word repetition than nonword repetition for polysyllabic items scored for PCC. There was not an interaction between time and Lexicality, i.e. the magnitude of Lexicality effect did not change over time. Performance of the two groups across time can be seen in Figure 5-13.

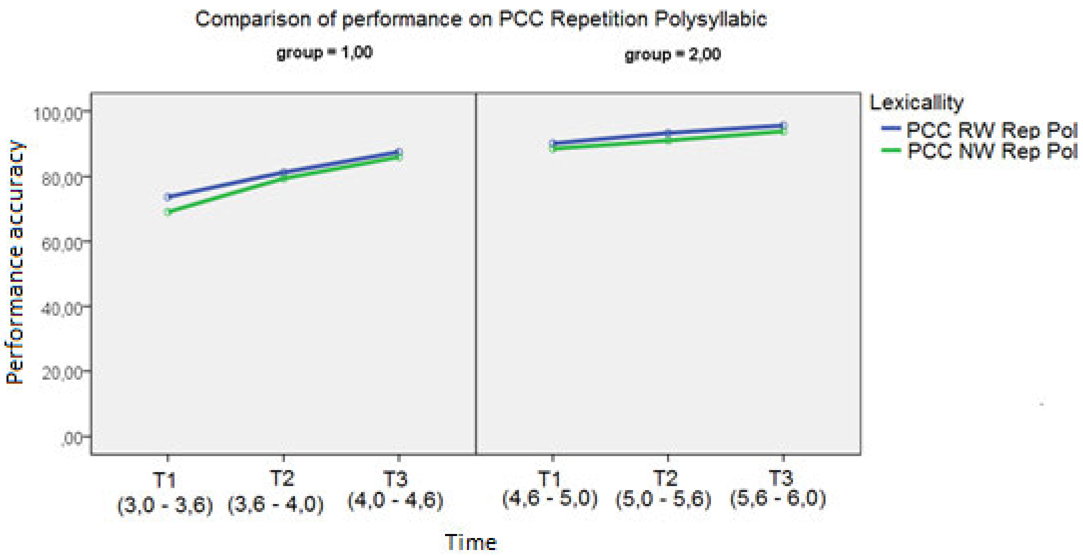

Figure 5-13 Repetition of RW and NW Polysyllabic items scored for whole word accuracy across time

5.1.3.6 Summary of the effect of lexicality in input and output tasks

To summarise the results on lexicality, a lexicality effect was evident in both groups of children in auditory discrimination of items of phonological interest and on all speech production tasks. Scoring on the number of items accurately repeated revealed an interaction between time and lexicality for polysyllabic items in Group 2 that was not evident when Percentage of Consonants Correct was used. Scoring on the number of phonological items accurately repeated did not indicate an effect of time for Group 2 whereas scoring for Percentage of Consonants Correct yielded an effect of time. Factor analysis supports the hypothesis that lexicality affects performance accuracy on output tasks, as well as on auditory discrimination of phonological stimuli.

5.1.4 Level of processing effect

Analysis yielded a Lexicality effect for the tasks of auditory discrimination of items of phonological interest and word repetition indicating that existing linguistic knowledge affects performance. Tasks requiring access to representations are considered to be more demanding than tasks where stored information can be used but it is not essential for the completion of the task (Sutherland & Gillon, 2007). It is therefore explored whether speech processing performance accuracy improves when children do not have to rely on stored representations for the successful completion of a task. The next step of analysis aimed to investigate performance on the same stimuli at different levels of processing, in particular to investigate if there is an effect of processing level when task demands require obligatory access to representations as opposed to when access to representations is optional. Therefore performance was compared for stimuli that share the same properties i.e. items of phonological interest, in tasks that tap different level of processing, specifically Real Word Auditory Discrimination in ABX and Picture Choice. Both tasks involve input processing of spoken words by the child. However, Real Word Auditory Discrimination does not require access to existing lexical representations, as the child can use bottom – up input processing skills to perceive the stimuli and discriminate. On the other hand Picture Choice requires access to previously stored information, as the child has to use top – down input processing in order to recognize the word heard and choose the corresponding picture. The literature cited in section 2.4.2 suggests that tasks requiring access to lexical representations are demanding, both within the course of typical development, and for children experiencing speech and/or language difficulties.

It is hypothesized that performance in Real Word Auditory Discrimination (RWAudD) will be significantly better than performance in Real Word Picture Choice (RWPicCh) for items of phonological interest within each age group between testing points.

5.1.4.1 Comparison of performance on Real Word ABX and Picture Choice Auditory Discrimination Tasks

A 3 (Time: T1, T2, T3) by 2 (Access to Representations: Optional, Obligatory) Repeated Measures ANOVAs was performed by group (Group 1, Group 2) with Bonferroni adjustment for multiple comparisons, taking number of items correct on Real Word Auditory Discrimination in ABX (as presented in Table 4-12) and Picture Choice (as presented in Table 4-15) tasks as the dependent variable. Analysis yielded a main effect of time for Group 1

($F_{(2,13)}$= 18.86, p<.001) and Group 2 ($F_{(2,16)}$=14.72, p<.001) and a main effect of level of processing for both Group 1 ($F_{(1,14)}$=6.68, p<.022) as well as Group 2 ($F_{(1,17)}$=6.38, p=.022). The main effect of time arose because performance in both tasks improved over time. The main effect of level of processing arose because children performed better on ABX auditory discrimination than on Picture Choice task, i.e. they performed better when it was not necessary to access stored lexical representations. Comparison of performance of the two groups across time points can be seen in Figure 5-14.

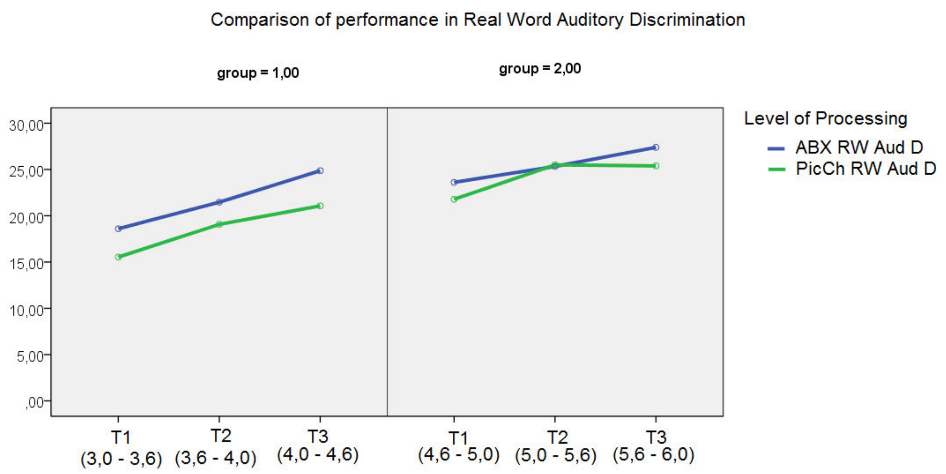

Figure 5-14 Real Word Auditory Discrimination in ABX and Picture Choice tasks across time points

It is not possible to compare Real Word Auditory Discrimination in ABX and Picture Choice tasks for items of morphological interest, because morphological items were presented in the Diagnostic Verbal IQ test – language comprehension within the context of a sentence and the picture format was different. Nor is it possible to compare performance in output tasks because different sets of stimuli were used in Naming (as presented in 3.3.2.i) and Real Word Repetition (as presented in 3.5.7). Comparison of auditory discrimination performance between ABX and Picture Choice tasks supports the hypothesis that children perform significantly better in ABX task, when access to representations is not obligatory.

5.1.5 Modality of processing effect

Research data indicate co-morbidity of difficulties with speech perception with speech production (Rvachew & Grawburg, 2006; Edwards et al. 2002) and language impairment (Ziegler, Pech-Georgel, George, & Lorenzi, 2011). It is explored whether processing of phonological and morphological elements of speech poses different demands in different modalities i.e. in input and output modality. The next set of analyses investigate whether there is a modality effect (input vs output) when the level of processing, in terms of whether or not lexical representations are accessed, is the same. A number of studies presented in section 2.4.1 provide research evidence that input processing difficulties coexist with speech difficulties. It is considered that in typical speech development there will be no difference between the input processing and production skills. Therefore, it is hypothesized that:

i. There will not be a significant difference between input and output modality in processing real words of phonological interest within each age group between testing points.
ii. There will not be a significant difference between input and output modality in processing real words of morphological interest within each age group between testing points
iii. There will not be a significant difference between input and output modality in processing nonwords of phonological interest within each age group between testing points.
iv. There will not be a significant difference between input and output modality in processing nonwords of morphological interest within each age group between testing points.

5.1.5.1 Comparison of performance on Real Word Auditory Discrimination (ABX) and Repetition of items of Phonological Interest

A 3 (Time: T1, T2, T3) by 2 (Modality: Input, Output) Repeated Measures ANOVA, with Bonferroni adjustment for multiple comparisons, was performed by group (Group 1, Group 2) taking the number of items correct on Real Word Auditory Discrimination in ABX task (as presented in Table 4-12) and Real Word Repetition using the Whole Word measure of items of Phonological interest (as presented in Table 4-19) as the dependent variable.

Analysis yielded a main effect of time both for Group 1 ($F_{(2,13)}$=27.05, p<.001) and Group 2 ($F_{(2,16)}$=12.59, p=.001). There was not a main effect of processing modality, nor an interaction between time and processing modality for any of Groups. The main effect of time arose because performance on tasks that involve processing of items of phonological interest with optional access to lexical representations improved over time. A main effect of processing modality did not arise because children scored similarly in input and output processing for items of phonological interest when access to representations was optional.

Performance of the two groups on the task can be seen in Figure 5-15.

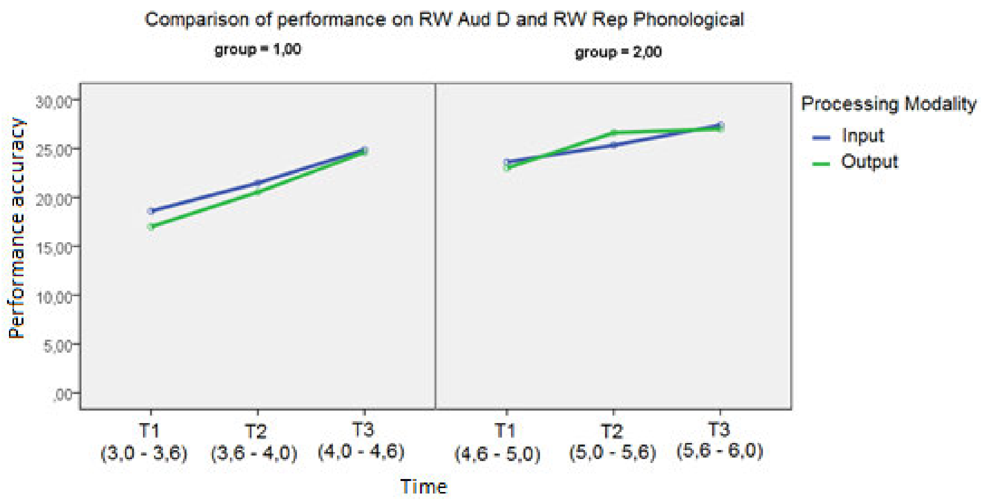

Figure 5-15 Input and Output processing of Real Words of phonological interest across time points

5.1.5.2 Comparison of performance on Real Word Auditory Discrimination (ABX) and Repetition of items of Morphological Interest

A 3 (Time: T1, T2, T3) by 2 (Modality: Input, Output) Repeated Measures ANOVA, with Bonferroni adjustment for multiple comparisons, was performed by group (Group 1, Group 2) taking the number of items correct on Real Word Auditory Discrimination in ABX task (presented in Table 4-13) and Real Word Repetition using the Whole Word measure of items of Morphological interest (presented in Table 4-19) as the dependent variable.

Analysis yielded a main effect of time both for Group 1 ($F_{(2,13)}$=32.59, p<.001) and Group 2 ($F_{(2,16)}$=7.53, p=.005). There was not a main effect of processing modality, nor an interaction between time and processing modality for either Group. The main effect of time arose because performance on the tasks improved over time. A main effect of processing modality did not arise because children scored in the same way in input and output processing for items of morphological interest when access to representations was optional. Performance of the two groups on the task can be seen in Figure 5-16.

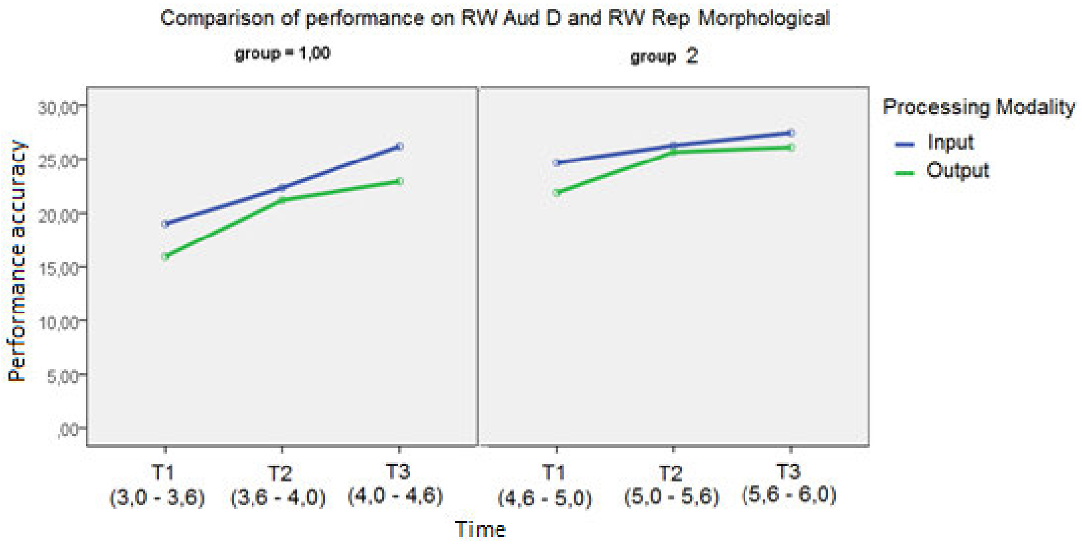

Figure 5-16 Input and Output processing of Real Words of morphological interest across time points

5.1.5.3 Comparison of performance on Nonword Auditory Discrimination (ABX) and Repetition of items of Phonological Interest

A 3 (Time: T1, T2, T3) by 2 (Modality: Input, Output) Repeated Measures ANOVA, with Bonferroni adjustment for multiple comparisons, was performed by group (Group 1, Group 2) taking the number of items correct on Nonword Auditory Discrimination in ABX task (presented in Table 4-10) and Nonword Repetition using the Whole Word measure of items of Phonological interest (presented in Table 4-24) as the dependent variable.

Analysis yielded a main effect of time both for Group 1 ($F_{(2,13)}$=19.11, p<.001) and Group 2 ($F_{(2,14)}$=12,01, p=.001). There was not a main effect of processing modality, nor an interaction between time and processing modality for any Group. The main effect of time arose because performance on the tasks that do not allow access to lexical representations improved over time. A main effect of processing modality did not arise because children scored similarly in input and output processing for items of phonological interest that do not have phonological representations. Performance of the two groups on the task can be seen in Figure 5-17.

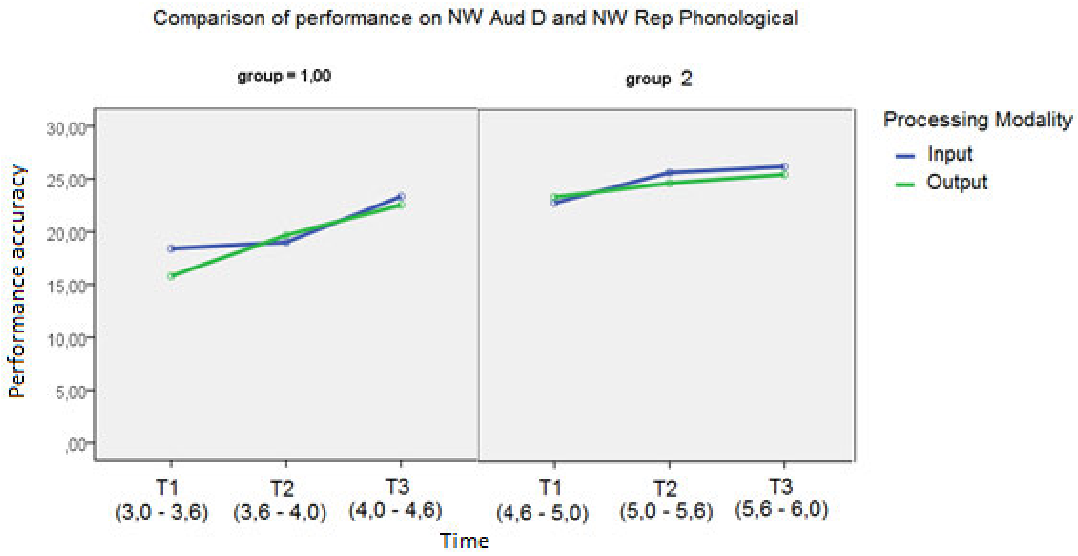

Figure 5-17 Input and Output processing of Nonwords of phonological interest across time points

5.1.5.4 Comparison of performance on Nonword Auditory Discrimination (ABX) and Repetition of items of Morphological Interest

A 3 (Time: T1, T2, T3) by 2 (Modality: Input, Output) Repeated Measures ANOVA, with Bonferroni adjustment for multiple comparisons, was performed by group (Group 1, Group 2) taking the number of items correct on Nonword Auditory Discrimination in ABX task (presented in Table 4-11) and Nonword Repetition using the Whole Word measure of items of Morphological interest (presented in Table 4-25) as the dependent variable.

Analysis yielded a main effect of time for Group 1 ($F_{(2,13)}$=33.44, p<.001) and a main effect of processing modality ($F_{(1,14)}$=4.63, p=0.49) as well as an interaction between time and processing modality ($F_{(2,13)}$=4.86, p=.026). Follow up paired samples t-tests were performed to investigate the nature of the main effects and the interaction (Table 5-9). The main effect of time arose because performance on the tasks improved significantly over time. The main effect of processing modality arose because children scored significantly higher on NWAudD than NWRep for items of morphological interest at T1. The interaction between time and processing modality arose because time did not affect performance on input and output tasks equally across time points (Figure 5-18).

Table 5-9 Paired samples comparison of performance in Nonwords of Morphological Interest between Auditory Discrimination and Repetition tasks for group 1

	t	df	Sig. (2-tailed)
T1NWAudDMor–T1NWRepMor	2.85	15	.012
T2NWAudDMor-T2NWRepMor	1.07	15	.300
T3NWAudDMor-T3NWRepMor	1.78	14	.097

Analysis yielded a main effect of time for Group 2 ($F_{(2,14)}$=4.14, p=.033) and a main effect of processing modality ($F_{(1,15)}$=4.91, p=.043). There was not an interaction between time and effect of processing modality. The main effect of time arose because performance improved significantly for NWAudDMor and NWRepMor over time. Follow up paired samples t-test indicate that the main effect of processing modality arose because children scored significantly higher (Table 5-10) on NWAudDMor than NWRepMor at T2 ($t_{(18)}$=2.34, p=.031) and at T3 (t(17)=2.66, p=.016). The magnitude of time effect on input and output performance was similar across time points. Performance of the two groups can be seen in Figure 5-18.

Table 5-10 Paired samples comparison of performance in Nonwords of Morphological Interest between Auditory Discrimination and Repetition tasks for group 2

	t	df	Sig. (2-tailed)
T1 NWAudDMor – T1 NWRepMor	1.32	18	.203
T2 NWAudDMor - T2 NWRepMor	2.34	18	.031
T3 NWAudDMor - T3 NWRepMor	2.66	17	.016

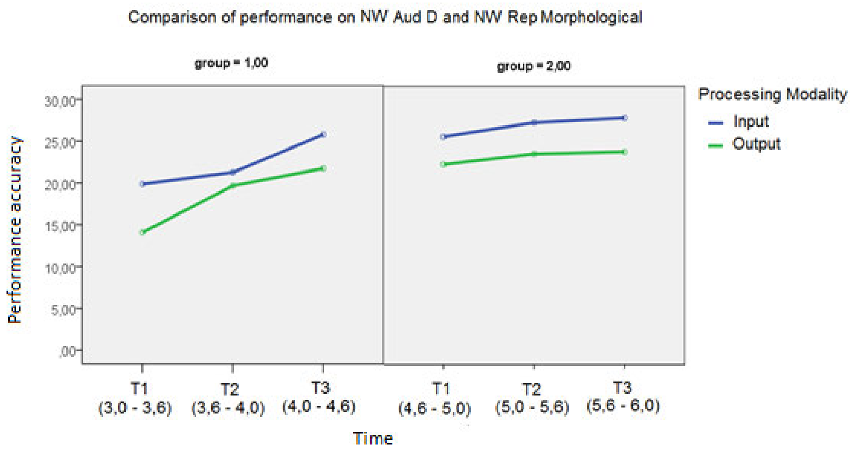

Figure 5-18 Input and Output processing of Nonwords of morphological interest across time

5.1.5.5 Summary

Comparison of performance of Real Word processing for items of phonological and morphological interest between input and output tasks did not yield an effect of processing modality on performance accuracy. Comparison of performance of nonword processing yielded an effect of processing modality in favour of auditory discrimination that was only evident in processing items of morphological interest and not phonological interest. It is worth noting that stimuli in Phonological tasks (as presented in Table 3-5) were closely matched phonological minimal pairs of 2-3 syllables. Stimuli in Morphological tasks (as presented in Table 3-3) were closely matched morphological pairs, quite often polysyllabic, which in certain cases were maximal pairs in terms of phonology. NW items of morphological interest were formed by changing the stressed vowel in word stem whereas inflectional characteristics were preserved. The effect of modality in processing nonwords of morphological interest may be related to factors such as wordlikeness, maximal opposition or stimuli length that were not controlled in this task. Comparison of performance between input and output tasks provides evidence in support of the hypothesis that there is not a significant difference in processing between the two modalities.

5.2 Relationships between the development of speech processing, language and short term memory

In the following section, possible associations between speech processing, language and short term memory are investigated. Correlational analysis is used to examine specific associations between processing of phonological and morphological items and more general associations with language and cognitive skills.

5.2.1 The relationship between processing of phonological and morphological items within and across time

In order to explore the development of morphological elements as part of the developing speech processing system, it is investigated whether there is a relationship between processing of phonological and morphological elements in input and output tasks. Comparison of performance in real word auditory discrimination (5.1.1.1) and real word repetition (5.1.1.2) tasks did not identify significant differences in processing of phonological and morphological items. It is therefore hypothesized that there will be a relationship between performance on phonological and morphological items when the level and modality of processing are similar. Specifically it is hypothesized that:

i. There will be a significant correlation between performance on input processing of phonological and morphological items as assessed in RWAudD ABX task.
ii. There will be a significant correlation between performance on output processing of phonological and morphological items as assessed in RWRep task.

5.2.1.1 The relationship between performance on phonological and morphological items in RWAudD ABX task within and across time

In order to examine the relationship between performance on phonological and morphological items in real word auditory discrimination, Pearson correlations were calculated within and across time for RWAudDPhon and RWAudDMor tasks.

The correlational matrix for group 1 (Table 5-11) shows that scores in auditory discrimination of phonological and morphological items are significantly associated within time points at T2 and T3 with a significant probability level of $p < 0.033$ (Bonferroni correction). Significant positive correlations were also found across time between RWAudDPhon at T2 and RWAudDMor at T3 and similarly between RWAudDMor at T2 and RWAudDPhon at T3.

Table 5-11 Correlations between performance on phonological and morphological items in real word auditory discrimination tasks for group 1

	T1RWAudDPhon	T2RWAudDPhon	T3RWAudDPhon	T1RWAudDMor	T2RWAudDMor	T3RWAudDMor
T1RWAudDPhon						
T2RWAudDPhon	.608**					
T3RWAudDPhon	.336	.819**				
T1RWAudDMor	.358	.249	.253			
T2RWAudDMor	.341	.616**	.669**	.274		
T3RWAudDMor	.135	.551**	.682**	.450	.390	

**. Correlation is significant at p<0.033 (Bonferroni correction)

The correlational matrix for group 2 (Table 5-12) shows that scores in auditory discrimination of phonological and morphological items are significantly associated within time at T1 and T3 with a significant probability level of p<0.033 (Bonferroni correction). A significant positive correlation was also found across time between RWAudDMor at T1 and RWAudDPhon at T3.

Table 5-12 Correlations between performance on phonological and morphological items in real word auditory discrimination tasks for group 2

	T1RWAudDPhon	T2RWAudDPhon	T3RWAudDPhon	T1RWAudDMor	T2RWAudDMor	T3RWAudDMor
T1RWAudDPhon						
T2RWAudDPhon	-.133					
T3RWAudDPhon	.696**	.191				
T1RWAudDMor	.547**	.356	.676**			
T2RWAudDMor	-.146	.154	-.008	.088		
T3RWAudDMor	.343	-.163	.525**	.546**	.043	

**. Correlation is significant at p<0.033 (Bonferroni correction)

5.2.1.2 The relationship between performance on phonological and morphological items in Real Word Repetition tasks within and across time

In order to examine the relationship between performance on phonological and morphological items in real word repetition, Pearson correlations were calculated within and across time for RWRepPhon and RWRepMor tasks scored for the whole word accuracy. The scoring for the overall accuracy of the word was used as it is more strict than the percentage of consonants correct, while in some cases the correct production of a phoneme is essential for the proper indication of a morpheme, as for example in the pairs [sɛɐˈftin] (*to her*) vs. [sɛɐˈfton] (*to him*), [tɐˈizun] (*are feeding*) vs. [tɐˈisun] (*will feed*).

The correlational matrix for group 1 (Table 5-13) shows that performance on real word repetition of phonological and morphological items are significantly associated within time at T1, T2 and T3 with a highly significant probability level of $p< 0.001$. Significant positive correlations were also found across time between RWRepPhon and RWRepMor at all time points, with a significant probability level of $p<0.033$ (Bonferroni correction) for the association between RWRepMor at T1 and RWRepPhon at T3.

Table 5-13 Correlations between performance on phonological and morphological items in real word repetition tasks for group 1

	T1RWRep Phon	T2RWRep Phon	T3RWRep Phon	T1RWRep Mor	T2RWRep Mor	T3RWRep Mor
T1RWRepPhon						
T2RWRepPhon	.843*					
T3RWRepPhon	.756*	.800*				
T1RWRepMor	.807*	.815*	.583**			
T2RWRepMor	.726*	.853*	.763*	.642*		
T3RWRepMor	.759*	.833*	.822*	.656*	.952*	

*. Correlation is significant at the 0.01 level (2-tailed).
**. Correlation is significant at p<0.033 (Bonferroni correction)

The correlation matrix for group 2 (Table 5-14) shows that real word repetition of phonological and morphological items are significantly associated within time at T1, T2 and T3 with a highly significant probability level of $p < 0.001$. Highly significant positive correlations were also found across time between RWRepPhon at T2 and RWRepMor at T3 and vice versa between RWRepMor at T2 and RWRepPhon at T3.

Table 5-14 Correlations between performance on phonological and morphological items in real word repetition tasks for group 2

	T1RWRep Phon	T2RWRep Phon	T3RWRep Phon	T1RWRep Mor	T2RWRep Mor	T3RWRep Mor
T1RWRepPhon						
T2RWRepPhon	.292					
T3RWRepPhon	.259	.854*				
T1RWRepMor	.731*	.226	.295			
T2RWRepMor	.309	.902*	.683*	.143		
T3RWRepMor	.373	.881*	.864*	.298	.889*	

*. Correlation is significant at the 0.01 level (2-tailed).
**. Correlation is significant at p<0.033 (Bonferroni correction)

5.2.1.3 Summary

In summary results for speech production indicate significant correlations at each time point between performance on stimuli of phonological and morphological interest. However, in group 1 significant correlation in output performance between phonological and morphological characteristics is frequently observed across time (diachronically), whereas in group 2 correlations in output performance between phonological and morphological characteristics are mainly observed within time (synchronically). This may indicate that for Group 1 participants, for whom change in the accuracy of the speech production performance over time is highly significant (as presented in section 4.2.5), speech production skills at a given point in time significantly associate with production skills in prior and subsequent time points. Results on the input side are less conclusive about a relationship between performance in phonological and morphological tasks, however, some significant correlations were found between processing of phonological and morphological items. Taken together these results suggest that there is an association between processing of phonological and morphological items within and across time.

5.2.2 The relationship between input and output processing in typically developing children within and across time

The different levels of processing are considered to form a system (Rees, 2001). Auditory discrimination difficulties have been related to speech sound disorders (Rvachew & Grawburg, 2006; Edwards et al. 2002) and language impairment (Ziegler, Pech-Georgel, George, & Lorenzi, 2011). Auditory discrimination is involved in the tasks of real and nonword repetition. Comparison of performance in input and output tasks as presented in section 5.1.5 did not yield an effect of the modality of processing. In order to explore the development of different components of the speech processing system, the relationship between input and output modalities is evaluated. Therefore it is hypothesized that there will be a relationship between performance in input and output processing tasks when stimuli characteristics are the same. Specifically it is hypothesized that:

i. There will be a significant correlation between RWAudD and RWRep for items of phonological interest
ii. There will be a significant correlation between RWAudD and RWRep for items of morphological interest
iii. There will be a significant correlation between NWAudD and NWRep for items of phonological interest
iv. There will be a significant correlation between NWAudD and NWRep for items of morphological interest

5.2.2.1 The relationship between real word auditory discrimination and real word repetition for items of phonological interest

In order to examine the relationship between performance on auditory discrimination and real word repetition for phonological items, Pearson correlations were calculated within and across time for RWAudDPhon and RWRepPhon tasks.

The correlational matrix for group 1 (Table 5-15) shows that scores in auditory discrimination and real word repetition for items of phonological interest are not significantly associated within nor across time. Significant positive correlations were found across time for RWAudDPhon between T1 and T2, T1 and T3. Highly significant correlations were also found on RWRepPhon performance across time.

Table 5-15 Correlations between performance on real word auditory discrimination and real word repetition for phonological items for group 1

	T1RWAuD Phon	T1RWAuD Phon	T1RWAuD Phon	T1RWRep Phon	T2RWRep Phon	T3RWRep Phon
T1RWAudDPhon						
T2RWAudDPhon	.608**					
T3RWAudDPhon	.336	.819*				
T1RWRepPhon	.520	.035	-.051			
T2RWRepPhon	.433	.283	.327	.843*		
T3RWRepPhon	.435	.171	.113	.756*	.800*	

*. Correlation is significant at the 0.01 level (2-tailed).
**. Correlation is significant at p<0.033 (Bonferroni correction)

The correlational matrix for group 2 (Table 5-16) shows that scores in auditory discrimination and real word repetition for items of phonological interest are not significantly associated within nor across time. A relationship between performance in the two tasks just missed significance at T1 ($p=.039$, correlation is significant at $p<0.033$ (Bonferroni correction). Highly significant positive correlation was found for RWAudDPhon between T1 and T3 and for RWRepPhon between T2 and T3.

Table 5-16 Correlations between performance on real word auditory discrimination and real word repetition for phonological items for group 2

	T1RWAudDP hon	T2RWAudDP hon	T3RWAudDP hon	T1RWRep Phon	T2RWRep Phon	T3RWRep Phon
T1RWAudDPhon						
T2RWAudDPhon	-.133					
T3RWAudDPhon	.696*	.191				
T1RWRepPhon	.457	-.090	.241			
T2RWRepPhon	.427	.435	.395	.292		
T3RWRepPhon	.489	.313	.504	.259	.854*	

*. Correlation is significant at the 0.01 level (2-tailed).

5.2.2.2 The relationship between real word auditory discrimination and real word repetition for items of morphological interest

In order to examine the relationship between performance on auditory discrimination and real word repetition for morphological items, Pearson correlations were calculated within and across time for RWAudDMor and RWRepMor tasks.

The correlational matrix for group 1 (Table 5-17) shows that scores in auditory discrimination and real word repetition for items of morphological interest are not significantly associated within nor across time. Highly significant correlations were found on RWRepMor across time.

Table 5-17 Correlations between performance on real word auditory discrimination and real word repetition for morphological items for group 1

	T1RWAudD Mor	T2RWAudD Mor	T3RWAudD Mor	T1RWRep Mor	T2RWRep Mor	T3RWRep Mor
T1RWAudDMor						
T2RWAudDMor	.274					
T3RWAudDMor	.450	.390				
T1RWRepMor	.474	.176	.283			
T2RWRepMor	.363	.497	.107	.642*		
T3RWRepMor	.290	.435	.065	.656*	.952*	

*. Correlation is significant at the 0.01 level (2-tailed).

The correlational matrix for group 2 (Table 5-18) shows that scores in auditory discrimination and real word repetition for items of morphological interest are not significantly associated within nor across time. A relationship was found on RWAudDMor between T1 and T3 and a highly significant correlation was found on RWRepMor between T2 and T3.

Table 5-18 Correlations between performance on real word auditory discrimination and real word repetition for morphological items for group 2

	T1RWAud DMor	T2RWAud DMor	T3RWAud DMor	T1RWRep Mor	T2RWRep Mor	T3RWRep Mor
T1RWAudDMor						
T2RWAudDMor	.088					
T3RWAudDMor	.546**	.043				
T1RWRepMor	.309	-.268	.174			
T2RWRepMor	.028	-.068	-.009	.143		
T3RWRepMor	.160	-.157	.190	.298	.889*	

**. Correlation is significant at p<0.033 (Bonferroni correction)
*. Correlation is significant at the 0.01 level (2-tailed).

5.2.2.3 The relationship between nonword auditory discrimination and nonword repetition for items of phonological interest

In order to examine the relationship between performance on auditory discrimination and nonword repetition for phonological items, Pearson correlations were calculated within and across time for NWAudDPhon and NWRepPhon tasks.

The correlational matrix for group 1 (Table 5-19) shows that scores in auditory discrimination and nonword repetition for items of phonological interest are not significantly associated within or across time. Highly significant correlations were found on NWRepPhon across time.

Table 5-19 Correlations between performance on nonword auditory discrimination and nonword repetition for phonological items for group 1

	T1NWAud DPhon	T2NWAud DPhon	T3NWAud DPhon	T1NWRep Phon	T2NWRep Phon	T3NWRep Phon
T1NWAudDPhon						
T2NWAudDPhon	-.161					
T3NWAudDPhon	.141	-.310				
T1NWRepPhon	.018	-.121	.064			
T2NWRepPhon	.167	-.106	.074	.860*		
T3NWRepPhon	.035	-.177	.063	.732*	.870*	

*. Correlation is significant at the 0.01 level (2-tailed).

The correlational matrix for group 2 (Table 5-20) shows that scores in auditory discrimination and nonword repetition for items of phonological interest are not significantly associated within or across time. Highly significant correlations were found on NWRepPhon across time.

Table 5-20 Correlations between performance on nonword auditory discrimination and nonword repetition for phonological items for group 2

	T1NWAud DPhon	T2NWAud DPhon	T3NWAud DPhon	T1NWRep Phon	T2NWRep Phon	T3NWRep Phon
T1NWAudDPhon						
T2NWAudDPhon	.402					
T3NWAudDPhon	.679*	.352				
T1NWRepPhon	.117	.177	.002			
T2NWRepPhon	.252	.189	.053	.835*		
T3NWRepPhon	.170	.107	-.032	.717*	.875*	

*. Correlation is significant at the 0.01 level (2-tailed).

5.2.2.4 The relationship between nonword auditory discrimination and nonword repetition for items of morphological interest

In order to examine the relationship between performance on auditory discrimination and nonword repetition for morphological items, Pearson correlations were calculated within and across time for NWAudDMor and NWRepMor tasks.

The correlational matrix for group 1 (Table 5-21) shows that scores in auditory discrimination and nonword repetition for items of morphological interest are not significantly associated within nor across time. Highly significant correlations were found on NWRepMor across time.

Table 5-21 Correlations between performance on nonword auditory discrimination and nonword repetition for morphological items for group 1

	T1NWAudD Mor	T2NWAudD Mor	T3NWAudD Mor	T1RWRep Mor	T2RWRep Mor	T3RWRep Mor
T1NWAudDMor						
T2NWAudDMor	.258					
T3NWAudDMor	.067	.303				
T1NWRepMor	.301	.473	.016			
T2NWRepMor	.422	.380	-.097	.827*		
T3NWRepMor	.334	.346	-.099	.804*	.930*	

*. Correlation is significant at the 0.01 level (2-tailed).

The correlational matrix for group 2 (Table 5-22) shows that scores in auditory discrimination and nonword repetition for items of morphological interest are not significantly associated within or across time. Highly significant correlations were found on NWAudDMor between T2 and T3 and on NWRepMor across time.

Table 5-22 Correlations between performance on nonword auditory discrimination and nonword repetition for morphological items for group 2

	T1NWAud DMor	T2NWAud DMor	T3NWAud DMor	T1RWRep Mor	T2RWRep Mor	T3RWRep Mor
T1NWAudDMor						
T2NWAudDMor	.326					
T3NWAudDMor	.350	.604*				
T1NWRepMor	.409	.354	.088			
T2NWRepMor	.477**	.358	.053	.973*		
T3NWRepMor	.361	.322	.250	.877*	.845*	

*. Correlation is significant at the 0.01 level (2-tailed).

5.2.2.5 Summary

In summary significant correlations were not found between performance in input i.e. ABX auditory discrimination task and output processing i.e. repetition task for items of phonological nor for items of morphological interest, whether stimuli were real words or nonwords. Interestingly, statistically significant relationships were found in performance both in input and output tasks across time points. Taken together these results suggest that for typically developing Greek speaking children at the age range of 3;0 – 4;5, 4;6 – 6;0 years there is not an association between input and output processing. Surprisingly, the results did not support the hypothesis for a relationship between input and output processing. This unexpected finding will be discussed in Chapter 7.

Input processing has been associated with language development (Tsao, 2004) and vocabulary (Edwards, 2002); therefore, the role of input processing in language development will be explored in section 5.2.3. As has already been shown (section 5.1.3), lexicality affects performance. Thus the role of vocabulary will be explored in subsequent analysis in section 5.2.4.

5.2.3 The relationship between speech input processing and language development

The aim of the next step in the analysis is to explore if there is a relationship between input processing and language development. Auditory discrimination skills have been found to correlate with later language development (Tsao, Liu, & Kuhl, 2004) and vocabulary (Edwards, 2002). Research data suggest that poor speech perception may explain poor word production (Ziegler, et al., 2011). In line with these findings is the suggestion that phonological processing correlates with language development (Chiat, 2001). Therefore it will be investigated if there is a relationship between language development and speech input processing, in particular processing of phonological and morphological elements. Specifically it is hypothesized that:

i. There will be a significant correlation between real word auditory discrimination of morphological items and language comprehension
ii. There will be a significant correlation between real word auditory discrimination of phonological items and vocabulary production.

5.2.3.1 The relationship between real word auditory discrimination (morphological) and language comprehension

In order to examine the relationship between performance on auditory discrimination of morphological items and language comprehension, Pearson correlations were calculated within and across time for RWAudDMor and DVIQC tasks (original task of language comprehension) as well as between RWAudDMor and DVIQCExp (matched experimental stimuli).

The correlational matrix for group 1 (Table 5-23) shows that scores in auditory discrimination and language comprehension are not significantly associated within nor across time, whether the language measurement is the original test of language comprehension or the experimental one with matched stimuli with the auditory discrimination task.

Table 5-23 Correlations between performance on real word auditory discrimination for morphological items and language comprehension for group 1

Original test items	T1RWAudD Mor	T2RWAudD Mor	T3RWAudD Mor	T1DVIQC	T2DVIQC	T3DVIQC

T1RWAudDMor						
T2RWAudDMor	.274					
T3RWAudDMor	.450	.390				
T1DVIQC	.314	-.069	-.160			
T2DVIQC	.405	.471	.141	.358		
T3DVIQC	.158	.147	-.170	.361	.560**	
Matched experimental Stimuli	T1RWAudD Mor	T2RWAudD Mor	T3RWAudD Mor	T1DVIQC EXP	T2DVIQC EXP	T3DVIQC EXP
T1RWAudDMor						
T2RWAudDMor	.274					
T3RWAudDMor	.450	.390				
T1DVIQCEXP	.158	.100	-.161			
T2DVIQCEXP	.151	.354	.077	.720*		
T3DVIQCEXP	.393	.162	-.032	.557**	.553**	

**. Correlation is significant at p<0.033 (Bonferroni correction)
*. Correlation is significant at the 0.01 level (2-tailed).

The correlational matrix for group 2 (Table 5-24) shows that scores in auditory discrimination and language comprehension are not significantly associated within nor across time, whether the language measurement is the original test of language comprehension or the experimental one with matched stimuli with the auditory discrimination task.

Table 5-24 Correlations between performance on real word auditory discrimination for morphological items and language comprehension for group 2

Original test items	T1RWAud DMor	T2RWAud DMor	T3RWAud DMor	T1DVIQC	T2DVIQC	T3DVIQC
T1RWAudDMor						
T2RWAudDMor	.088					
T3RWAudDMor	.546**	.043				
T1DVIQC	.108	-.084	.117			
T2DVIQC	-.146	-.163	-.015	.053		
T3DVIQC	.210	-.058	.170	.135	.482**	
Matched experimental Stimuli	T1RWAudD Mor	T2RWAudD Mor	T3RWAudD Mor	T1DVIQC EXP	T2DVIQC EXP	T3DVIQC EXP
T1RWAudDMor						
T2RWAudDMor	.088					
T3RWAudDMor	.546**	.043				
T1DVIQCEXP	-.100	-.266	-.313			
T2DVIQCEXP	.165	.023	-.231	-.032		
T3DVIQCEXP	.128	-.234	-.326	-.019	.834*	

**.Correlation is significant at p<0.033 (Bonferroni correction)
*. Correlation is significant at the 0.01 level (2-tailed).

5.2.3.2 The relationship real word auditory discrimination (phonological) and vocabulary production

In order to examine the relationship between performance on auditory discrimination of phonological items and vocabulary production, Pearson correlations were calculated within and across time for RWAudDPhon and Vocab tasks.

The correlational matrix for group 1 (Table 5-25) shows that scores in auditory discrimination and vocabulary production are not significantly associated within or across time.

Table 5-25 Correlations between performance on real word auditory discrimination for phonological items and vocabulary production for group 1

	T1RWAudD Phon	T2RWAudD Phon	T3RWAudD Phon	T1Vocab	T2Vocab	T3Vocab
T1RWAudDPhon						
T2RWAudDPhon	.608**					
T3RWAudDPhon	.336	.819*				
T1Vocab	.224	.089	-.045			
T2Vocab	.140	.109	.026	.863*		
T3Vocab	.256	.150	.069	.882*	.895*	

**. Correlation is significant at p<0.033 (Bonferroni correction)
*. Correlation is significant at the 0.01 level (2-tailed).

The correlational matrix for group 2 (Table 5-26) shows that scores in auditory discrimination and vocabulary production are significantly associated within time at T3. There is also a significant relationship between vocabulary production at T2 and RWAudDPhon at T3.

Table 5-26 Correlations between performance on real word auditory discrimination for phonological items and vocabulary production for group 2

	T1RWAudD Phon	T2RWAudD Phon	T3RWAudD Phon	T1Vocab	T2Vocab	T3Vocab
T1RWAudDPhon						
T2RWAudDPhon	-,133					
T3RWAudDPhon	,696*	,191				
T1Vocab	,174	,291	,445			
T2Vocab	,455	,210	,527**	,796*		
T3Vocab	,418	,361	,509**	,777*	,921*	

**. Correlation is significant at p<0.033 (Bonferroni correction)
*. Correlation is significant at the 0.01 level (2-tailed).

In summary significant correlations were not found between RWAudDMor and DVIQC within nor across time. A significant relationship was found between RWAudDPhon and Vocab for group 2 at T3. It seems that there are a limited number of significant relationships between input processing with output processing and language. Results did not provide evidence in support of the hypothesis between input processing with language development. This unexpected finding is discussed in chapter 7. Analysis moves on to explore the relationship between vocabulary and the integrity of phonological representations and phonological awareness skills (section 5.2.4) as well as language (section 5.2.5).

5.2.4 The relationship between vocabulary development, accuracy of stored phonological representations and phonological awareness

Vocabulary growth (Metsala & Walley, 1998) is thought to lead to the formation of more accurate representations and the development of explicit segmentation. It is explored whether the formation of accurate representations within the speech processing system relates to vocabulary development and the development of phonological awareness skills. Given the frequency of polysyllabic words in the Greek language the possible relationship between vocabulary and the accuracy of stored representations is investigated both for 2-3 syllable words and for polysyllabic words. Therefore it is hypothesized that:

i. There will be a significant correlation between vocabulary production and accuracy of stored phonological representations for 2 – 3 syllable words.
ii. There will be a significant correlation between vocabulary production and accuracy of stored phonological representations for polysyllabic words
iii. There will be a significant correlation between vocabulary production and naming accuracy
iv. There will be a significant correlation between vocabulary production and segmentation skills.

5.2.4.1 The relationship between vocabulary production and accuracy of stored phonological representations

In order to examine the relationship between performance on vocabulary production and accuracy of stored phonological representations for 2 – 3 syllable words, Pearson correlations were calculated within and across time for Vocab and RWAudPicCh tasks.

The correlational matrix for group 1 (Table 5-27) shows that scores in vocabulary production and auditory discrimination with picture choice are significantly associated within time at all time points. Significant positive correlations were also found across time.

Table 5-27 Correlations between performance on vocabulary production and real word auditory discrimination with picture choice for group 1

	T1Vocab	T2Vocab	T3Vocab	T1RWPicCh	T2RWPicCh	T3RWPicCh
T1Vocab						
T2Vocab	.863*					
T3Vocab	.882*	.895*				
T1RWPicCh	.510**	.584**	.487			
T2RWPicCh	.755*	.773*	.771*	.511**		
T3RWPicCh	.495	.515**	.549**	.477	.716*	

*. Correlation is significant at the 0.01 level (2-tailed).
**. Correlation is significant at $p<0.033$ (Bonferroni correction)

The correlational matrix for group 2 (Table 5-28) shows that scores in vocabulary production and auditory discrimination with picture choice are significantly associated within time at T2. Significant positive correlations were also found across time between Vocab T1 and RWPicCh T3 and RWPicCh T2 and Vocab T3.

Table 5-28 Correlations between performance on vocabulary production and real word auditory discrimination with picture choice for group 2

	T1Vocab	T2Vocab	T3Vocab	T1RWPicCh	T2RWPicCh	T3RWPicCh
T1Vocab						
T2Vocab	.796*					
T3Vocab	.777*	.921*				
T1RWPicCh	.272	.187	.203			
T2RWPicCh	.413	.492**	.484**	.340		
T3RWPicCh	.548**	.262	.401	.327	.299	

*. Correlation is significant at the 0.01 level (2-tailed).
**. Correlation is significant at $p<0.033$ (Bonferroni correction)

5.2.4.2 The relationship between vocabulary production and accuracy of stored phonological representations for polysyllabic words

In order to examine the relationship between performance on vocabulary production and accuracy of stored phonological representations for polysyllabic words, Pearson correlations were calculated within and across time for Vocab and MisprD tasks.

The correlational matrix for group 1 (Table 5-29) shows that scores in vocabulary production and mispronunciation detection are significantly associated within time at T1 and T2. A relationship was also found between MisprD T1 and Vocab T2.

Table 5-29 Correlations between performance on vocabulary production and mispronunciation judgment for group 1

	T1Vocab	T2Vocab	T3Vocab	T1MisPrJ	T2MisPrJ	T3MisPrJ
T1Vocab						
T2Vocab	.863*					
T3Vocab	.882*	.895*				
T1MisPrD	.681*	.509**	.477			
T2MisPrD	.362	.515**	.478	.024		
T3MisPrD	-.088	.008	-.008	.233	.429	

*. Correlation is significant at the 0.01 level (2-tailed).
**. Correlation is significant at p<0.033 (Bonferroni correction)

The correlational matrix for group 2 (Table 5-30) shows that scores in vocabulary production and mispronunciation detection are significantly associated within time at T3. A significant relationship was also found between Vocab T1 and MisprD T2.

Table 5-30 Correlations between performance on vocabulary production and mispronunciation judgment for group 2

	T1Vocab	T2Vocab	T3Vocab	T1MisPrJ	T2MisPrJ	T3MisPrJ
T1Vocab						
T2Vocab	.796*					
T3Vocab	.777*	.921*				
T1MisPrD	.251	.008	.134			
T2MisPrD	.460**	.346	.436	.448		
T3MisPrD	.334	.371	.513**	.161	-.027	

*. Correlation is significant at the 0.01 level (2-tailed).
**. Correlation is significant at p<0.033 (Bonferroni correction)

5.2.4.3 The relationship between vocabulary production and naming accuracy

In order to examine the relationship between performance on vocabulary production and naming accuracy, which reflects on the accuracy of stored motor programs, Pearson correlations were calculated within and across time for Vocab and Naming tasks.

The correlational matrix for group 1 (Table 5-31) shows that scores in vocabulary production and naming accuracy are significantly related within time at T2 and T3. Significant relationships are also found across time between performance on Vocab T1 and Naming T2, Naming T2 and Vocab T3.

Table 5-31 Correlations between performance on vocabulary production and naming accuracy for group 1

	T1Vocab	T2Vocab	T3Vocab	T1Naming	T2Naming	T3Naming
T1Vocab						
T2Vocab	.863*					
T3Vocab	.882*	.895*				
T1Naming	.375	.306	.383			
T2Naming	.548**	.499**	.620**	.844*		
T3Naming	.486	.403	.635*	.786*	.840*	

*. Correlation is significant at the 0.01 level (2-tailed).
**. Correlation is significant at p<0.033 (Bonferroni correction)

The correlational matrix for group 2 (Table 5-32) shows highly significant relationships between performance in vocabulary production and naming accuracy within and across time at all time points.

Table 5-32 Correlations between performance on vocabulary production and naming accuracy for group

	T1Vocab	T2Vocab	T3Vocab	T1Naming	T2Naming	T3Naming
T1Vocab						
T2Vocab	.796*					
T3Vocab	.777*	.921*				
T1Naming	.805*	.741*	.693*			
T2Naming	.677*	.722*	.696*	.936*		
T3Naming	.611*	.598*	.623*	.890*	.919*	

*. Correlation is significant at the 0.01 level (2-tailed).

5.2.4.4 The relationship between phonological awareness and vocabulary production

In order to examine the relationship between performance on vocabulary production and phonological awareness, Pearson correlations were calculated within and across time for Vocab and Segmentation tasks.

The correlational matrix for group 1 (Table 5-33) shows that scores in vocabulary production and segmentation accuracy are significantly related within time at T3. A significant relationship is also found across time between performance Vocab T1 and segmentation T3.

Table 5-33 Correlations between performance on vocabulary production and segmentation for group 1

	T1Vocab	T2Vocab	T3Vocab	T1Segm	T2Segm	T3Segm
T1Vocab						
T2Vocab	.863*					
T3Vocab	.882*	.895*				
T1Segm	.312	.479	.419			
T2Segm	.248	.237	.360	.414		
T3Segm	.585**	.491	.585**	.156	.581**	

*. Correlation is significant at the 0.01 level (2-tailed).
**. Correlation is significant at p<0.033 (Bonferroni correction)

The correlational matrix for group 2 (Table 5-34) shows that scores in vocabulary production and segmentation accuracy are significantly related within time at T1 and T3. Significant relationships are also found across time between performance Segmentation T1 and Vocab at T2 and T3, segmentation T3 and Vocab T1, T2.

Table 5-34 Correlations between performance on vocabulary production and segmentation for group 2

	T1Vocab	T2Vocab	T3Vocab	T1Segm	T2Segm	T3Segm
T1Vocab						
T2Vocab	.796*					
T3Vocab	.777*	.921*				
T1Segm	.530**	.539**	.477**			
T2Segm	.402	.437	.322	.650*		
T3Segm	.592*	.609*	.523**	.452	.752*	

*. Correlation is significant at the 0.01 level (2-tailed).
**. Correlation is significant at p<0.033 (Bonferroni correction)

5.2.4.5 Summary

In summary significant correlations were found between vocabulary production and accuracy of stored phonological representations both for 2 – 3 syllable words and polysyllabic words, particularly for group 1. Vocabulary production and naming accuracy were also significantly related, particularly for group 2. Results provide evidence in support of the hypothesis for a significant relationship between vocabulary production with the accuracy of stored phonological representations and naming. Statistically significant relationships were found between segmentation and vocabulary production within and across time. Interestingly these relationships were observed more often in group 2, i.e. children who have developed segmentation skills beyond the syllable level (as presented in section 4.3.2).

5.2.5 The relationship between vocabulary production, language development and phonological awareness

Taken together results in 5.2.4 suggest that vocabulary production relates to the development of stored lexical representations and phonological awareness. According to the literature, vocabulary knowledge relates to language comprehension in Greek speaking children (Chrysochoou & Bablekou, 2011). It is suggested that PA emerges earlier in highly inflected languages such as Greek because children rely on segmentation skills in order to cope with inflections. For the better understanding of how the comprehension and production of morphology develops in Greek children, the development of language competence (as assessed in language comprehension and production tasks) is investigated in relation to the development of parameters such as vocabulary and phonological awareness. In the next analysis, the relationship between vocabulary and language development is explored, as well as the relationship between phonological awareness and language development. It is hypothesized that:

i. There will be a significant correlation between vocabulary production and language comprehension
ii. There will be a significant correlation between vocabulary production and elicited language production
iii. There will be a significant correlation between vocabulary production and spontaneous language production
iv. There will be a significant correlation between segmentation and language comprehension
v. There will be a significant correlation between segmentation and language production.

5.2.5.1 The relationship between vocabulary production and language comprehension

In order to examine the relationship between performance on vocabulary production and language comprehension, Pearson correlations were calculated within and across time for Vocab and DVIQC tasks.

The correlational matrix for group 1 (Table 5-35) shows that scores in vocabulary production and language comprehension are significantly associated within time at T1 and T2. Significant positive correlations were also found across time between DVIQC at T1 and T2 with Vocab at all time points.

Table 5-35 Correlations between performance on vocabulary production and language comprehension for group 1

	T1Vocab	T2Vocab	T3Vocab	T1DVIQC	T2DVIQC	T3DVIQC
T1Vocab						
T2Vocab	.863*					
T3Vocab	.882*	.895*				
T1DVIQC	.792*	.590**	.671*			
T2DVIQC	.514**	.514**	.633*	.358		
T3DVIQC	.485	.397	.368	.361	.560**	

*. Correlation is significant at the 0.01 level (2-tailed).
**. Correlation is significant at p<0.033 (Bonferroni correction)

The correlational matrix for group 2 (Table 5-36) shows that scores in vocabulary production at all time points are significantly related to language comprehension at T3.

Table 5-36 Correlations between performance on vocabulary production and language comprehension for group 2

	T1Vocab	T2Vocab	T3Vocab	T1DVIQC	T2DVIQC	T3DVIQC
T1Vocab						
T2Vocab	.796*					
T3Vocab	.777*	.921*				
T1DVIQC	.122	.117	.193			
T2DVIQC	.323	.060	.080	.053		
T3DVIQC	.553**	.528**	.494**	.135	.482**	

*. Correlation is significant at the 0.01 level (2-tailed).
**. Correlation is significant at p<0.033 (Bonferroni correction)

5.2.5.2 The relationship between vocabulary production and elicited language production

In order to examine the relationship between performance on vocabulary production and elicited language production, Pearson correlations were calculated within and across time for Vocab and DVIQP tasks.

The correlational matrix for group 1 (Table 5-37) shows that performance in DVIQP significantly correlates with Vocab at T1. Significant correlations between performance in the two tasks at T1 and T3 are also found across time.

Table 5-37 Correlations between performance on vocabulary production and elicited language production for group 1

	T1Vocab	T2Vocab	T3Vocab	T1DVIQP	T2DVIQP	T3DVIQP
T1Vocab						
T2Vocab	.863*					
T3Vocab	.882*	.895*				
T1DVIQP	.759*	.608**	.784*			
T2DVIQP	.356	.314	.480	.661*		
T3DVIQP	.571**	.425	.616**	.731*	.844*	

*. Correlation is significant at the 0.01 level (2-tailed).
**. Correlation is significant at $p<0.033$ (Bonferroni correction)

The correlational matrix for group 2 (Table 5-38) shows that scores in vocabulary production and elicited language production are significantly associated within time at T2 and T3. Significant correlations between performance in the two tasks at T2 and T3 are also found across time.

Table 5-38 Correlations between performance on vocabulary production and elicited language production for group 2

	T1Vocab	T2Vocab	T3Vocab	T1DVIQP	T2DVIQP	T3DVIQP
T1Vocab						
T2Vocab	.796*					
T3Vocab	.777*	.921*				
T1DVIQP	.370	.467**	.403			
T2DVIQP	.577*	.536**	.560**	.432		
T3DVIQP	.534**	.525**	.483**	.285	.521**	

*. Correlation is significant at the 0.01 level (2-tailed).
**. Correlation is significant at $p<0.033$ (Bonferroni correction)

5.2.5.3 The relationship between vocabulary production and spontaneous language production

In order to examine the relationship between performance on vocabulary production and spontaneous language production, Pearson correlations were calculated within and across time for Vocab and MLU as assessed in Bus story test.

The correlational matrix for group 1 (Table 5-39) shows that performance in BusMLU significantly correlates with Vocab within and across time at all time points.

Table 5-39 Correlations between performance on vocabulary production and MLU for group 1

	T1Vocab	T2Vocab	T3Vocab	T1BusMLU	T2BusMLU	T3BusMLU
T1Vocab						
T2Vocab	.863*					
T3Vocab	.882*	.895*				
T1BusMLU	.687*	.646*	.614**			
T2BusMLU	.682*	.646*	.603**	.603**		
T3BusMLU	.631**	.673*	.762*	.631**	.651**	

*. Correlation is significant at the 0.01 level (2-tailed).
**. Correlation is significant at p<0.033 (Bonferroni correction)

The correlational matrix for group 2 (Table 5-40) shows that performance in BusMLU significantly correlates with Vocab within time at T2. Significant correlations between BusMLU at T2 with Vocab performance at T1 and T3 are also found across time.

Table 5-40 Correlations between performance on vocabulary production and MLU for group 2

	T1Vocab	T2Vocab	T3Vocab	T1BusMLU	T2BusMLU	T3BusMLU
T1Vocab						
T2Vocab	.796*					
T3Vocab	.777*	.921*				
T1BusMLU	.324	.271	.153			
T2BusMLU	.511**	.655*	.610*	.369		
T3BusMLU	.419	.324	.311	.221	.353	

*. Correlation is significant at the 0.01 level (2-tailed).
**. Correlation is significant at p<0.033 (Bonferroni correction)

5.2.5.4 The relationship between phonological awareness and language comprehension

In order to examine the relationship between performance on language comprehension and segmentation skills, Pearson correlations were calculated within and across time for DVIQC and Segm tasks.

The correlational matrix for group 1 (Table 5-41) shows that scores in DVIQC and Segm are not significantly associated within or across time.

Table 5-41 Correlations between performance on language comprehension and segmentation for group 1

	T1DVIQC	T2DVIQC	T3DVIQC	T1Segm	T2Segm	T3Segm
T1DVIQC						
T2DVIQC	.358					
T3DVIQC	.361	.560**				
T1Segm	.077	.336	.120			
T2Segm	.227	.152	-.106	.414		
T3Segm	.630**	.295	.020	.156	.581**	

**. Correlation is significant at p<0.033 (Bonferroni correction)

The correlational matrix for group 2 (Table 5-42) shows that performance in DVIQC at T3 significantly correlates with Segm performance at all time points.

Table 5-42 Correlations between performance on language comprehension and segmentation for group 2

	T1DVIQC	T2DVIQC	T3DVIQC	T1Segm	T2Segm	T3Segm
T1DVIQC						
T2DVIQC	.053					
T3DVIQC	.135	.482**				
T1Segm	.110	.407	.734*			
T2Segm	.114	.355	.675*	.650*		
T3Segm	.022	.331	.680*	.452	.752*	

**. Correlation is significant at p<0.033 (Bonferroni correction)
*. Correlation is significant at the 0.01 level (2-tailed).

5.2.5.5 The relationship between phonological awareness and language production

In order to examine the relationship between performance on language comprehension and segmentation skills, Pearson correlations were calculated within and across time for DVIQP and Segm tasks.

The correlational matrix for group 1 (Table 5-43) shows that scores in DVIQP at T1 and Segm at T3 are significantly associated across time.

Table 5-43 Correlations between performance on language production and segmentation for group 1

	T1DVIQP	T2DVIQP	T3DVIQP	T1Segm	T2Segm	T3Segm
T1DVIQP						
T2DVIQP	.661*					
T3DVIQP	.731*	.844*				
T1Segm	.069	.016	-.015			
T2Segm	.300	.114	-.009	.414		
T3Segm	.622**	.183	.383	.156	.581**	

*. Correlation is significant at the 0.01 level (2-tailed).
**. Correlation is significant at p<0.033 (Bonferroni correction)

The correlational matrix for group 2 (Table 5-44) shows a significant correlation between the two tasks at T2. Segm performance at T1 significantly correlates across time with DVIQP at T2, T3.

Table 5-44 Correlations between performance on language production and segmentation for group 2

	T1DVIQP	T2DVIQP	T3DVIQP	T1Segm	T2Segm	T3Segm
T1DVIQP						
T2DVIQP	.432					
T3DVIQP	.285	.521**				
T1Segm	.413	.704*	.530**			
T2Segm	.353	.520**	.224	.650*		
T3Segm	.085	.407	.296	.452	.752*	

**. Correlation is significant at p<0.033 (Bonferroni correction)
*. Correlation is significant at the 0.01 level (2-tailed).

5.2.5.6 Summary

In summary significant correlations were found between vocabulary production and language measurements, particularly for group 1. Some significant correlations were found across time between performance in segmentation and language tasks. Results provide evidence in support of the hypothesis for a relationship between vocabulary production and language development.

5.2.6 The relationship between short term memory, language and speech processing

Short term memory (STM) is thought to influence vocabulary development (Gathercole & Baddeley, 1989), language comprehension (Florit, Roch, Altoe, & Levorato, 2009), language production (Adams & Gathercole, 1995, 2000) and syntax (Blake, Mysczyszyn & Jokel, 2004). For the better understanding of the development of language skills and speech processing skills development it is investigated whether these skills relate to the development of STM skills. Analysis moves on to explore the role of STM in language development and speech processing. It is hypothesized that

i. There will be a significant correlation between STM and vocabulary production.
ii. There will be a significant correlation between STM and language comprehension
iii. There will be a significant correlation between STM and language production
iv. There will not be a significant correlation between STM and auditory discrimination tasks.

5.2.6.1 The relationship between short term memory and vocabulary production

In order to examine the relationship between performance on STM and language production, Pearson correlations were calculated within and across time for STM tasks and Vocab. Pearson correlations were calculated for the number of words correctly recalled from a list of words (MemoryW), for the number of word lists correctly recalled in order (MemoryO) and the sentence repetition subtest of DVIQ test (DVIQSR). Sentence repetition has been suggested as a language measurement (Seeff-Gabriel, Chiat, & Dodd, 2010). It has also been argued that performance in sentence repetition reflects the capacity of PSTM (Willis & Gathercole, 2001). Therefore it is included in this analysis of STM skills.

The correlational analysis for group 1 (Table 5-45) shows that scores in Vocab and DVIQSR correlate within time at T1 and T2 and across time T2DVIQSR with T3Vocab. However, these results would not maintain significance under Bonferroni correction; therefore need to be interpreted with caution.

Table 5-45 Correlations between performance on STM tasks and Vocabulary production for group 1

	T1Vocab	T2Vocab	T3Vocab
T1MemoryW	.407	.185	.259
T2MemoryW	.207	.146	.319
T3MemoryW	.185	.039	.294
T1MemoryO	.326	.149	.245
T2MemoryO	.376	.346	.482
T3MemoryO	.365	.237	.429
T1DVIQSR	.499(*)	.398	.480
T2DVIQSR	.325	.527(*)	.504(*)
T3DVIQSR	.340	.390	.329

(*) Correlation is significant at the 0.05 level (2-tailed) without Bonferroni correction

The correlational analysis for group 2 (Table 5-46) shows that scores in Vocab and DVIQSR correlate within time at T1. A correlation that would not maintain significance under Bonferroni correction is found between T1Vocab and T2DVIQ.

Table 5-46 Correlations between performance on STM tasks and Vocabulary production for group 2

	T1Vocab	T2Vocab	T3Vocab
T1MemoryW	.314	.380	.462
T2MemoryW	-.124	.090	.192
T3MemoryW	-.010	.238	.329
T1MemoryO	.364	.351	.446
T2MemoryO	.072	.119	.220
T3MemoryO	.063	.323	.448
T1DVIQSR	.632*	.310	.435
T2DVIQSR	.514(*)	.198	.265
T3DVIQSR	.322	.105	.165

*Correlation is significant at the 0.01 level (2-tailed).
(*) Correlation is significant at the 0.05 level (2-tailed) without Bonferroni correction

5.2.6.2 The relationship between short term memory and language comprehension

In order to examine the relationship between performance on STM and language comprehension, Pearson correlations were calculated within and across time for STM tasks and DVIQC.

The correlational analysis for group 1 (Table 5-47) shows that scores in DVIQC significantly correlate within time with MemoryW, MemoryO at T1 and with MemoryW, MemoryO and DVIQSR at T2. Significant across time correlations are found between DVIQC at T2 with MemoryO and MemoryW at T3.

Table 5-47 Correlations between performance on STM tasks and language comprehension for group 1

	T1DVIQC	T2DVIQC	T3DVIQC
T1MemoryW	.725*	.317	.387
T2MemoryW	.217	.537**	.396
T3MemoryW	.298	.637**	.300
T1MemoryO	.611**	.301	.248
T2MemoryO	.376	.640*	.366
T3MemoryO	.434	.579**	.374
T1DVIQSR	.345	.420	.308
T2DVIQSR	.310	.537**	.184
T3DVIQSR	.399	.514(*)	.528(*)

*Correlation is significant at the 0.01 level (2-tailed).
**. Correlation is significant at p<0.033 (Bonferroni correction)
(*) Correlation is significant at the 0.05 level (2-tailed) without Bonferroni correction

The correlational analysis for group 2 (Table 5-48) shows that DVIQC at T3 significantly correlates across time with DVIQSR at T1 and T2.

Table 5-48 Correlations between performance on STM tasks and language comprehension for group 2

	T1DVIQC	T2DVIQC	T3DVIQC
T1MemoryW	.019	.043	.010
T2MemoryW	.154	-.339	.182
T3MemoryW	-.144	-.228	.090
T1MemoryO	.159	.218	.239
T2MemoryO	.053	-.138	.276
T3MemoryO	-.043	-.144	.152
T1DVIQSR	.192	.239	.499(*)
T2DVIQSR	.160	.396	.762*
T3DVIQSR	.221	.184	.433

*Correlation is significant at the 0.01 level (2-tailed)
(*) Correlation is significant at the 0.05 level (2-tailed) without Bonferroni correction

5.2.6.3 The relationship between short term memory and language production

In order to examine the relationship between performance on STM and language production, Pearson correlations were calculated within and across time for STM tasks and DVIQP.

Correlational analysis for group 1 (Table 5-49) shows that language production significantly correlates within time with DVIQSR at all time points. Significant correlations are also found between MemoryW and MemoryO at T3 with DVIQP at all time points.

Table 5-49 Correlations between performance on STM tasks and language production for group 1

	T1DVIQP	T2DVIQP	T3DVIQP
T1MemoryW	.498	.326	.494
T2MemoryW	.391	.438	.357
T3MemoryW	.576**	.762*	.673*
T1MemoryO	.447	.287	.457
T2MemoryO	.547**	.457	.421
T3MemoryO	.583**	.737*	.686*
T1DVIQSR	.528**	.532**	.606**
T2DVIQSR	.426	.574**	.447
T3DVIQSR	.295	.651*	.566**

*Correlation is significant at the 0.01 level (2-tailed).
**. Correlation is significant at p<0.033 (Bonferroni correction)

Correlational analysis for group 2 (Table 5-50) shows that significant correlations are only found between DVIQSR and DVIQP within and across time.

Table 5-50 Correlations between performance on STM tasks and language production for group 2

	T1DVIQP	T2DVIQP	T3DVIQP
T1MemoryW	.367	.031	.169
T2MemoryW	.339	.054	.248
T3MemoryW	.398	.351	-.083
T1MemoryO	.252	0.000	.193
T2MemoryO	.332	.085	.296
T3MemoryO	.293	.228	-.041
T1DVIQSR	.571*	.595*	.551**
T2DVIQSR	.383	.647*	.391
T3DVIQSR	.603*	.267	.200

*Correlation is significant at the 0.01 level (2-tailed).
**. Correlation is significant at p<0.033 (Bonferroni correction)

5.2.6.4 The relationship between short term memory and auditory discrimination

Short term memory is a prerequisite for the completion of ABX auditory discrimination task, as maintenance of at least the first two items is necessary for the children to decide on the similarity or difference of stimuli. Stimuli were chosen with the aim of being developmentally sensitive in terms of phonological characteristics. However, performance on the task was below chance level for group 1. It is assumed that if performance on the auditory discrimination task reflects on the development of the speech processing system rather than STM abilities, there will not be a correlation between performance on auditory discrimination and STM tasks. In order to examine the relationship between STM and auditory discrimination Pearson correlations were calculated within and across time for performance on a task requiring the repetition of items in the correct order (MemoryO) and RWAudDPhon and RWAudDMor tasks.

Correlational analysis for group 1 (Table 5-51) shows that scores in RWAudD tasks and MemoryO are not significantly related within or across time.

Table 5-51 Correlations between performance on STM Word order task and ABX auditory discrimination tasks for group 1

	T1MemoryO	T2MemoryO	T3MemoryO
T1RWAudDPhon	-.058	.094	.150
T2RWAudDPhon	.116	.330	.281
T3RWAudDPhon	.186	.384	.337
T1RWAudDMor	.218	.429	.406
T2RWAudDMor	-.050	.415	.274
T3RWAudDMor	.190	.242	.116

Correlational analysis for group 2 (Table 5-52) shows that scores in RWAudD tasks and MemoryO are not significantly related either within or across time.

Table 5-52 Correlations between performance on STM Word order task and ABX auditory discrimination tasks for group 2

	T1MemoryO	T2MemoryO	T3MemoryO
T1RWAudDPhon	.452	.400	.268
T2RWAudDPhon	.034	-.165	.165
T3RWAudDPhon	.207	.352	.347
T1RWAudDMor	.470	.341	.438
T2RWAudDMor	-.053	.145	-.015
T3RWAudDMor	.443	.295	.295

5.2.6.5 Summary

In summary correlational analysis yielded a relationship between vocabulary production and DVIQSR for group 1 that would not maintain significance under Bonferroni correction. Significant correlations were found within and across time between MemoryO, MemoryW and DVIQSR with language comprehension and production for group 1. Performance on language tasks was significantly correlated only with DVIQSR task for group 2. There were no significant correlations between performance on ABXAudD task and MemoryO for any of the groups.

Results provide evidence in support of the hypothesis for a relationship between short term memory tasks with language comprehension and production for Group 1. It seems that this relationship declines early on in children speaking the Greek language, therefore it was not observed in Group 2. Results provide evidence in support of the hypothesis that auditory discrimination performance, as assessed on this study with this range of tasks, is not related to short term memory performance. Results on the relationship of short term memory with language and speech processing skills are discussed in chapter 7.

5.2.7 The relationship between production of polysyllabic items with short term memory, accuracy of stored phonological representations and segmentation skills

Production of polysyllabic items has been found to relate to STM skills (Gathercole, 2006), accuracy of stored phonological representations (Vance, 2004) and segmentation abilities (Snowling, 1981). Since polysyllabic words are frequent in Greek, it is explored whether the same relationships between the development of polysyllabic words with STM skills and speech processing skills that have been found for children who speak English also apply to children who speak Greek. It is hypothesized that there will be significant correlations between the accuracy of polysyllabic word production and

i. Short term memory
ii. The accuracy of stored phonological representations
iii. Segmentation skills

5.2.7.1 The relationship between production of polysyllabic words and short term memory

In order to examine the relationship between STM and accuracy of polysyllabic word production, Pearson correlations were calculated within and across time between performances on an STM task scoring the number of words recalled (MemoryW) and the RWRepPol scored for PCC, as PCC was shown to be the more sensitive measure.

The correlational matrix for group 1 (Table 5-53) shows that there are no statistically significant correlations between the two tasks within or across time.

Table 5-53 Correlations between performance on Repetition of polysyllabic items and STM for group 1

	T1RWRep Polpcc	T2RWRep Polpcc	T3RWRep Polpcc	T1MemoryW	T2MemoryW	T3MemoryW
T1RWRepPolpcc						
T2RWRepPolpcc	.933*					
T3RWRepPolpcc	.905*	.932*				
T1MemoryW	-.150	-.219	-.069			
T2MemoryW	-.018	.057	.231	.501		
T3MemoryW	.177	.214	.385	.581**	.785*	

*. Correlation is significant at the 0.01 level (2-tailed).

**. Correlation is significant at p<0.033 (Bonferroni correction)

Correlational matrix for group 2 (Table 5-54) shows that there are no statistically significant correlations between the two tasks within or across time.

Table 5-54 Correlations between performance on Repetition of polysyllabic items and STM for group 2

	T1RWRep Polpcc	T2RWRep Polpcc	T3RWRep Polpcc	T1MemoryW	T2MemoryW	T3MemoryW
T1RWRepPolpcc						
T2RWRepPolpcc	.937*					
T3RWRepPolpcc	.907*	.906*				
T1MemoryW	.169	.048	.063			
T2MemoryW	.086	-.056	-.082	.587**		
T3MemoryW	.071	.048	-.137	.394	.483**	

*. Correlation is significant at the 0.01 level (2-tailed).

**. Correlation is significant at p<0.033 (Bonferroni correction)

5.2.7.2 The relationship between production of polysyllabic words and accuracy of stored phonological representations.

In order to examine the relationship between the accuracy of stored phonological representations and accuracy of polysyllabic word production, Pearson correlations were calculated within and across time for performance on MisprD and RWRepPol scored for PCC.

The correlation matrix for group 1 (Table 5-55) shows that performance on MisprD at T2 significantly correlates with RWRepPolPCC at all time points.

Table 5-55 Correlations between performance on Repetition of polysyllabic items and accuracy of stored representations for group 1

	T1MisPrJ	T2MisPrJ	T3MisPrJ	T1RWRep Polpcc	T2RWRep Polpcc	T3RWRep Polpcc
T1MisPrJ						
T2MisPrJ	.024					
T3MisPrJ	.233	.429				
T1RWRepPolpcc	.112	.666*	.200			
T2RWRepPolpcc	.087	.622**	.272	.933*		
T3RWRepPolpcc	.005	.708*	.405	.905*	.932*	

*. Correlation is significant at the 0.01 level (2-tailed).
**. Correlation is significant at p<0.033 (Bonferroni correction)

The correlation matrix for group 2 (Table 5-56 Correlations between performance on Repetition of polysyllabic items and accuracy of stored representations for group 2) shows that MisprD at T2 significantly correlates with RWRepPolPCC at T1 and T2.

Table 5-56 Correlations between performance on Repetition of polysyllabic items and accuracy of stored representations for group 2

	T1MisPrJ	T2MisPrJ	T3MisPrJ	T1RWRepP olpcc	T2RWRepP olpcc	T3RWRepP olpcc
T1MisPrJ						
T2MisPrJ	.448					
T3MisPrJ	.161	-.027				
T1RWRepPolpcc	.196	.565**	.445			
T2RWRepPolpcc	.287	.591*	.302	.937*		
T3RWRepPolpcc	.282	.341	.390	.907*	.906*	

*. Correlation is significant at the 0.01 level (2-tailed).
**. Correlation is significant at p<0.033 (Bonferroni correction)

5.2.7.3 The relationship between polysyllabic word production and segmentation

In order to examine the relationship between segmentation skills and the accuracy of polysyllabic word production, Pearson correlations were calculated within and across time for performance on Segm and RWRepPol scored for PCC, which has proved to be a more sensitive measurement.

The correlational matrix for group 1 (Table 5-57) shows that there are no significant correlations between the two tasks within or across time.

Table 5-57 Correlations between performance on Repetition of Polysyllabic items and segmentation skills for group 1

	T1RWRep Polpcc	T2RWRep Polpcc	T3RWRep Polpcc	T1Segm	T2Segm	T3Segm
T1RWRepPolpcc						
T2RWRepPolpcc	.933*					
T3RWRepPolpcc	.905*	.932*				
T1Segm	-.046	.131	.119			
T2Segm	.214	.344	.269	.414		
T3Segm	.405	.314	.375	.156	.581**	

*. Correlation is significant at the 0.01 level (2-tailed).
**. Correlation is significant at p<0.033 (Bonferroni correction)

The correlational matrix for group 2 (Table 5-58) shows that RWRepPolPCC at T1 and T2 significantly correlates across time with Segm performance at T3.

Table 5-58 Correlations between performance on Repetition of Polysyllabic items and segmentation skills for group 2

	T1RWRepP olpcc	T2RWRepP olpcc	T3RWRepP olpcc	T1Segm	T2Segm	T3Segm
T1RWRepPolpcc						
T2RWRepPolpcc	.937*					
T3RWRepPolpcc	.907*	.906*				
T1Segm	.325	.346	.159			
T2Segm	.380	.389	.349	.650*		
T3Segm	.616**	.502**	.432	.452	.752*	

*. Correlation is significant at the 0.01 level (2-tailed).
**. Correlation is significant at p<0.033 (Bonferroni correction)

5.2.7.4 Summary

In summary correlational analysis did not yield a significant relationship between production of polysyllabic items and short term memory for either group. Performance on Mispronunciation Detection at T2 was found to significantly correlate with Real Word Repetition of Polysyllabic items scored for PCC within and across time for both groups. No significant relationship was found between segmentation and Real Word Repetition of Polysyllabic items for group 1, however Segmentation performance at T1 and T2 was found to significantly correlate with Real Word Repetition of Polysyllabic items for group 2. Results provide evidence in support of the hypothesis for a relationship between the accuracy of stored phonological representations and repetition of polysyllabic items. Furthermore, results provide evidence in support of a relationship between segmentation skills with repetition of polysyllabic items. A diachronic relationship was found for group 2 between repetition accuracy for polysyllabic items (at T1 and T2) with subsequent development of segmentation skills at T3.

5.3 Summary of findings

This chapter has investigated the factors affecting performance and the possible relationships between speech processing, language and STM in typically developing Greek speaking children aged 3;0-4;6, 4;6-6;0.

The first factor to be investigated was linguistic domain. The results presented in Chapter 4 revealed an effect of age on children's performance in processing items of phonological and morphological interest. It was hypothesized that speech processing requirements are similar for any spoken-word material and that there would not be a significant difference in performance accuracy between phonological and morphological items i.e. that there would not be a significant linguistic domain effect. Results indicate that there is not a significant difference in performance between phonological and morphological items in ABX auditory discrimination tasks. This finding has to be treated with caution, because of the below chance performance of Group 1 on discrimination tasks. A statistically significant difference between phonological and morphological items in repetition accuracy was not found at any of the assessment points, when the whole word scoring method was used. PCC scoring indicated a linguistic domain effect in favour of morphological items, significant at T1 and T2 performance of Group 1. These findings are discussed in section 7.2.1.1.

The second factor investigated was word length. It was hypothesized that repetition accuracy on 2-3 syllables items would be significantly better than on 4-5 syllables items. Indeed, repetition accuracy was significantly better on shorter compared to longer stimuli for Group 1 at all time points in repetition of real words and nonwords. For Group 2 there was a significant difference in favour of 2-3 syllables items that was only evident at T1 and T2. Results provide evidence in support of the hypothesis for a word length effect in performance. The word length factor is discussed in section 7.2.1.2

The third factor to be explored was Lexicality. It was hypothesized that performance in speech processing tasks would be significantly better when real word stimuli compared to nonword stimuli are used. A lexicality effect was found for Group 1 in auditory discrimination of items of phonological interest and for both groups of children on all speech production tasks. The results realing to a lexicality effect are discussed in section 7.2.1.3.

The fourth factor to be explored was the level of processing. It was hypothesized that children would perform better when there is the possibility of accessing stored lexical representations, but it is not mandatory to access representations for the completion of the task, compared to tasks that require children to rely on stored representations. Results are discussed in section 7.2.1.4.

The fifth and final factor to be investigated was modality of processing. It was hypothesized that input and output processing performance would not be significantly different, provided that input and output tasks tap on the same level of processing. There was not a significant difference between input and output processing performance, in processing real word stimuli of phonological and morphological interest and nonword stimuli of phonological interest. However, modality of processing seems to have affected performance on nonword stimuli of morphological interest. Findings are discussed in section 7.2.1.5.

Then, Pearson correlational analyses were used to examine specific associations between speech processing of phonological and morphological items and more general associations with language and cognitive skills.

A significant relationship was found between processing of phonological and morphological items. This provides further evidence in support of the hypothesis that morphological items, compared to phonological items, do not pose specific challenges in terms of speech processing. The relationship between processing of phonological and morphological items is further discussed in 7.2.2.1.

Strong significant relationships were found between different output production tasks but not between auditory discrimination and speech production, nor between vocabulary production and naming accuracy. These results suggest that there is a strong relationship between performance accuracy on speech production tasks tapping different levels of processing. However, there is no evidence for a relationship between auditory discrimination and output production (discussed in section 7.2.2.2) or language (discussed in section 7.2.2.3) in the typically developing children studied here.

Vocabulary production was found to be strongly related to the accuracy of stored phonological representations and phonological awareness as well as language comprehension and production. The role of vocabulary in the development of precise phonological representations is discussed in section 7.2.2.4. A significant relationship was also found between performance on language tasks and segmentation skills, which is discussed in section 7.2.2.5.

A significant relationship was found between language comprehension and short term memory particularly for group 1, but there was no significant relationship between short term memory and vocabulary production or between short term memory and language production. It is noteworthy that the task that most often correlated significantly with language comprehension and production measurements, particularly for group 2, was sentence repetition. Findings on the relationships between short term memory, language and speech processing are discussed in section 7.2.2.6.

Finally, the relationship between production of polysyllabic items with short term memory and speech processing skills was explored. Polysyllabic words are frequently used in Greek (as presented in section 1.4) and may be revealing of speech production difficulties (James et al. 2008; James, 2006; Vance et al. 2005). Therefore, it was important to investigate skills relating to accurate repetition of polysyllabic items. Word length was found to affect performance on output tasks. Polysyllabic word repetition was found to correlate with the other output production tasks and mispronunciation judgment but not with short term memory tasks. For group 2 Real Word Repetition of Polysyllabic items scored for PCC also correlated significantly with vocabulary production and segmentation skills across time.

Findings on the relationship between performance in polysyllabic items with short term memory and speech processing skills are discussed in section 7.2.2.7.

The aim of the current thesis is to apply a psycholinguistic framework of speech processing in order to investigate the development of phonological and morphological skills in Greek speaking children. Development of language, speech processing and short term memory skills over time was the focus of chapter 4. This chapter has investigated the factors affecting performance and the possible relationships between speech processing, language and short term memory in typically developing Greek speaking children aged 3;0-4;6, 4;6-6;0. The next chapter presents two intervention single case studies of Greek children with speech difficulties. Children were assessed with the same assessment battery that was used in the longitudinal study. Subsequently children received intervention targeting the accurate production of phonological and morphological targets. The outcome of intervention is evaluated with the aim of informing our understanding of the role of the speech processing system in the development of phonological and morphological components of the language.

Chapter 6. Intervention Case studies

The aim of the current thesis is to apply a psycholinguistic framework of speech processing in order to investigate the development of phonological and morphological skills in Greek speaking preschool age children. In chapters 3-5, this has been explored through a longitudinal normative study of speech and language development. On most of the matched tasks there was no significant difference between morphological and phonological results. Moreover, in correlational analysis, a significant relationship was found between processing of phonological and morphological items. This provides evidence in support of the hypothesis that morphological items, compared to phonological items, do not pose specific challenges in terms of speech processing.

In this chapter, the relationship is explored through intervention case studies of two Greek-speaking children with speech and / or language difficulties. The intervention case studies presented in the current chapter assess and profile children who do not have the necessary speech processing skills for the accurate production of a phoneme that is used in a morphological context. It is explored how speech difficulties may be manifested in language production, i.e. how may the production of morphophonemes be affected by speech processing difficulties and what should be the aim of intervention. On the basis of the strong relationship between phonological and morphological processing in normal development that was reported in Chapters 4 and 5, it is hypothesised that intervention targeting specific speech processing skills may lead to the accurate production of morphemes.

The production of /s/ that is a phoneme with multiple morphological functions in Greek was assessed and targeted in intervention. The principles of a psycholinguistic approach formed the basis for intervention delivery. Outcome is evaluated in the broader context of the speech processing system, with respect to changes in the production of morphology. On the basis of studies reviewed in chapter 2 and discussed below in section 6.2, it is hypothesised that the children's response to intervention may provide evidence to theoretical questions regarding the organization of the speech processing system, as to whether the morphological features of words form an integral part of the lexical representations, or whether there are discrete representations for individual morphemes, distinct from the word semantics and phonological form.

By addressing these hypotheses, the investigation of children with speech difficulties may elucidate our understanding of the development of the speech processing system and the development of language skills. Intervention outcome from these single case studies may be informative for clinicians working with Greek speaking children. It may also have theoretical implications for clinicians and researchers.

6.1 Issues in single case study design – general principles in developing intervention

In single case studies one participant or a small number of participants receive intervention. The specific difficulties that the participant is experiencing, the provision of intervention and response to treatment are described in detail. Experimental single case studies are designed in such a way as to guarantee experimental control and provide answers to specific research questions.

Single case study design can be adapted to intervention in a range of childhood difficulties such as specific language impairment (SLI) (Norbury & Chiat, 2000), word finding difficulties (Stiegler & Hoffman, 2001) and unintelligible speech (Pascoe, Stackhouse, & Wells, 2005).

Frequently a theoretical framework is used to support clinical decisions for a particular child. Single case study research has been used to evaluate the efficacy of traditional articulation therapy (Holm, Dodd, & Ozanne, 1997), stimulability intervention (Miccio & Elbert, 1996), psycholinguistic approach (Bryan & Howard, 1992;Pascoe, et al., 2005; Waters, Hawkes, & Burnett, 1998), core vocabulary approach (Crosbie, Pine, Holm, & Dodd, 2006; McIntosh & Dodd, 2008) and Parents And Children Together (Bowen & Cupples, 1998).

It is important to control for factors beyond intervention, so as to ensure that any noticeable change is the result of intervention and not the consequence of maturation, or environmental conditions (Pascoe, Stackhouse, & Wells, 2006). According to Pring (2005), there are three ways to create a control condition in a single case study: a) to compare performance on treated and untreated items, the latter functioning as controls for treated items (as used by Seeff-Gabriel, Chiat, & Pring, 2012), b) to compare performance on an untreated area as a control for a treated area (as used by Norbury & Chiat, 2000), c) to monitor changes in a treated area during periods of no treatment and treatment (as used by Pascoe, et al., 2005). Experimental tasks and published assessments may be used pre intervention as well as post intervention to provide a baseline against which any change is evaluated.

In order to accomplish the definitive objective of intervention research to identify the most effective intervention for each case, a comprehensive description of participant and intervention is vital (Ebbels, 2014). Intervention studies should report on the participant characteristics such as age, severity, pervasiveness, co-morbidity of difficulties, as well as a detailed description of the conditions under which intervention is delivered. Joffe & Serry, (2004) draw attention to the detailed description of therapy techniques, including instructions to parents, to facilitate comparison and interpretation of studies based on evidence based practice.

6.2 Background to the intervention case studies

Since the eighties, it has been proposed that potential interactions between the levels of the language system may influence the linguistic performance of a person with communication difficulties. Crystal (1987) puts emphasis on the need for further research to establish the standpoint of a 'bucket' theory of language disability, 'there is I believe a strong case for the more systematic study of the interaction between linguistic levels in the field of language disability' p.15 (Crystal, 1987). Language difficulties frequently co-occur with speech difficulties (Broomfield & Dodd, 2004; Haskill & Tyler, 2007; Mortimer & Rvachew, 2010; Nathan, Stackhouse, & Goulandris, 1998; Shriberg, Tomblin, & McSweeny, 1999; Tyler, Gillon, Macrae, & Johnson, 2011). Researchers (Haskill & Tyler, 2007; Mortimer & Rvachew, 2010; Rvachew, Gaines, Cloutier, & Blanchet, 2005) raise the question whether morphological errors of children with speech disorders are a reflection of their phonological weaknesses.

Rvachew, et al. (2005) explored the connection between errors in speech production and expressive language. Four year old children attending speech therapy were assessed in a story retelling task with the aim to compare the production of /s/, /z/ in inflected (plural, possessive, third person singular) and uninflected words in word initial and final positions. Production accuracy of /s/, /z/ with morphological function was lower compared with the production of the same phonemes in the monomorphemic condition. Difficulty with inflection production was particularly evident in the case of the simple present - third person singular morpheme. The authors came to the conclusion that difficulties with inflection production exceeded difficulties with word final singleton and cluster /s/, /z/, thus speech difficulties could not fully account for difficulties with morphology.

The possible association between morphological errors and underpinning phonological errors was investigated in depth in subgroups of children with language impairment and varying degrees of speech difficulties by Haskill & Tyler (2007). Finite verb morpheme production (i.e. third person singular *–s*, regular past tense *–ed*, auxiliary and copula *be* forms) and non-finite morpheme production (i.e. articles, possessives and regular noun plurals) were compared for four groups of children: (a) language impairment only, (b) speech-language impairment with minimal or no final cluster reduction/ consonant deletion, (c) speech-language impairment with frequent final cluster reduction/ consonant deletion and (d) no-impairment control group. Production of finite and non-finite morphemes was similar for participants facing difficulties solely with language and the control group. Both groups produced finite third person singular forms significantly less accurately than non-finite noun plurals. The language impairment only group performed on morpheme production significantly better than children with language impairment and final cluster reduction/ consonant deletion. Haskill & Tyler (2007) suggested that co morbidity of speech and language difficulties might have a cumulative effect on morphological production, beyond the degree of difficulty that would be expected in the presence of language impairment alone. However, it is worth noting that production of finite morphemes was higher than production of non-finite morphemes for all groups. This discrepancy in production of phonologically similar yet grammatically different forms suggests that phonological characteristics cannot fully provide an explanation for morphological errors: 'the ability to produce final consonants in nonmorphemic probes may not be an adequate indicator of a child's speech "sufficiency" for producing morphophonemes' (Haskill & Tyler, 2007; p.218).

A longitudinal investigation of morphosyntactic development of children with speech sound disorders by Mortimer & Rvachew (2010) revealed that children who have poor finite verb morphology combined with low MLU in pre-kindergarten, have limited expressive language two years later. However, a low finite verb morphology score is not necessarily associated with low MLU in all cases of children with speech difficulties.

It is important to investigate to what extent difficulties with expressive morphology may be attributed to speech production errors (Haskill & Tyler, 2007; Rvachew, et al., 2005) as well as the impact that therapy on one domain may have on another (Seeff-Gabriel, et al., 2012; Tyler, Lewis, Haskill, & Tolbert, 2002, 2003). It is assumed that there is an interaction between phonology and other linguistic levels, although the nature of the interaction is not yet clear (Tyler, 2002). Provision of intervention for children with primary speech and/or language difficulties has proven to bring about change compared with no treatment (Broomfield & Dodd, 2011). Nevertheless, provision of the most effective intervention for each case remains a challenge, as it is not yet clear which specific changes occur because of which specific intervention.

The purpose of the current intervention case studies was to investigate the effect of intervention on the development of speech production skills in relation to phonological and morphological targets. The findings of intervention studies in English speaking children (Seeff-Gabriel, et al., 2012; Tyler,et al., 2002, 2003) indicate that intervention addressing morphological targets may have a positive effect on phonological aspects of speech and vice versa. The findings of the normative study for the development of the speech processing skills in Greek speaking children, presented in Chapters 4 and 5, provide evidence that similar input and output skills are necessary for processing phonological and morphological aspects of language, the pattern of development is similar and relationships can be found between the development of these skills. Thus both the research literature and the findings from the present study indicate that the development of phonology and morphology are based on similar speech processing skills. It is expected that whether the focus of intervention is on phonological or morphological elements, generalization may occur to the untreated domain. It is anticipated that as a result of intervention targeting either phonological or morphological components there will be positive effect on speech processing skills in general. In order to investigate this hypothesis, the production of /s/ was targeted in different intervention phases with the focus of intervention alternating between phonological and morphological components. Changes in the production of treated targets and generalization to untreated targets were then measured at each phase of the intervention. The overall effect of the intervention on the children's broader speech and language processing skills was also assessed.

The following research questions are addressed:

1. Once /s/ is realised by the child in a particular phonotactic structure is there generalization to the production of the same phoneme in other structures?
2. Once /s/ is realized by the child in a particular morpheme is there generalization to the production of other morphemes that also require the production of /s/?

3. What is the effect of phonologically oriented intervention for /s/ on production of grammatical morphemes that require the production of this phoneme?
4. What is the effect of morphologically oriented speech therapy intervention on the production of /s/ as part of the phonological system?
5. Is there a change in the child's general speech and language abilities as a result of this intervention?

6.3 Methodology

6.3.1 Participants

In order to be included in the study participants fulfilled the following criteria:

- Have normal hearing and vision (or vision corrected to normal when wearing glasses), to ensure that no sensory deficits affect the development of speech processing skills.
- Speak Greek as their first or home language, to ensure that there are no effects of bilingualism in language development.
- Have some production difficulty with /s/ as this is the phonological and morphological target for intervention.
- Either have language difficulties as indicated by ≤ -1.5 S.D. from age matched controls performance on language tasks or have speech difficulties as indicated by ≤ -1.5 S.D. from age matched controls performance on PPC in naming tasks. The criterion of -1.5 S.D. below the mean performance of typically developing children is sensitive in identifying children who need speech and language therapy intervention. Since the focus of the current study is the interaction between phonological and morphological characteristics, alternative selection criteria are set and participants could face difficulties either in speech or in language.
- Age at least 4; 0 years old, since in the phonological development of typically developing children (presented in Table 1-3), the production of the phoneme /s/ has been acquired at the age of four and the phonological process of final consonant deletion in close syllable is eliminated when the syllable is at the end of the word.

Four children referred for speech and/ or language difficulties in a setting of private practice fulfilled the selection criteria and were recruited for the study. Children had never received speech therapy assessment or speech therapy intervention in the past. Parents were provided with an information letter describing in brief the purpose of the research project and conditions of intervention delivery. Informed parental consent and child assent was gained for two children, one boy (Harry) and one girl (Anthi).

6.3.1.1 Participant 1:

Harry was 4; 2 years old at the time of first assessment, and starting to attend school at pre-kindergarten level. There was no history of pre- or perinatal problems or medical problems. He had achieved developmental milestones as expected. The family consisted of Harry, an older sister studying at 4th grade and the parents who were both university graduates and were both working. Harry performed within the expected range for his age in language comprehension (DVIQC) and language production (DVIQP) tasks; however, performance on experimental stimuli met the criterion of – 1.5 S.D. both in language comprehension (DVIQCExp) and language production (DVIQPExp) tasks. Naming accuracy also met the criterion of – 1.5 S.D. below the mean. Harry's performance in the complete test battery is compared to data from typically developing children in Table 6-4.

6.3.1.2 Participant 2:

Anthi was 5; 7 years old at the time of first assessment, and attending school at kindergarten level. There was no history of pre- or perinatal problems or medical problems. She had achieved developmental milestones as expected. The family consisted of Anthi, a younger sister, two parents who had completed secondary education and were both working and grandmother who was the main caregiver. Anthi met the criterion of – 1.5 S.D. below the mean in all language tasks. Her naming accuracy is slightly above the threshold of - 1.5 S.D. below the mean. However, repetition accuracy falls well below the expected for her age in real word and nonword repetition tasks. Anthi's performance in the complete test battery in compared to data from typically developing children in Table 6-9.

6.3.2 Design

A single subject research design was used. Pre-intervention assessment was carried out twice: two months before and immediately prior to the beginning of the intervention. Four Phases of intervention were performed. There was an alternating focus on phonological characteristics of targets (at odd-numbered intervention Phases) and morphological characteristics of targets (at the even-numbered intervention Phases) as presented in Figure 6-1. Post-intervention assessment was carried out twice: immediately upon completion and two months following completion of the intervention. The test battery used in the longitudinal study (as presented in Chapter 3) was used pre- and post-intervention as a baseline macro assessment to monitor broad changes in speech and language abilities. In order to measure therapy-specific changes a number of stimuli were used to collect repeated measures at a micro-level of probe assessment before and during the intervention Phases. The research design can be seen in Figure 6-1.

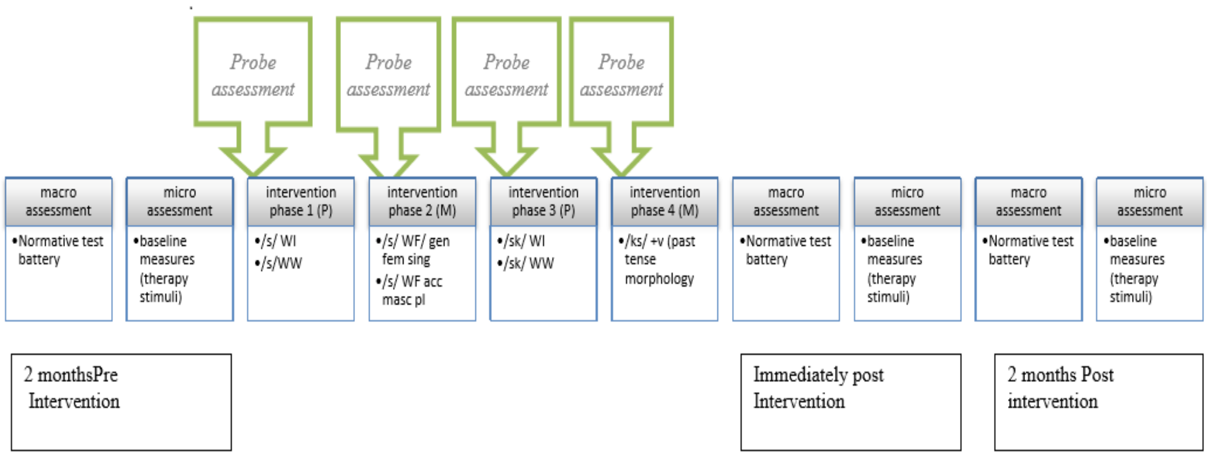

Figure 6-1 Research design

6.3.3 Intervention phases

6.3.3.1 Phase 1:

The first Phase of the intervention focused on the production of /s/ for phonological purposes, when it is included in the word stem. The phoneme was targeted in syllable initial (SI) Consonant Vowel (CV) structure and not in consonant clusters, at word initial (WI) position for example [ˈsinɛfo] (cloud) and word within (WW) position for example [niˈsi] (island), [cɛˈɾɐsi] (cherry). There were 20 SIWI and 20 SIWW treated items. Six intervention sessions were designed. The complete set of treated items can be seen in Appendix 6.

6.3.3.2 Phase 2:

The second Phase of the intervention focused on the production of /s/ for morphological purposes, when it is included in the word ending. The phoneme was targeted in syllable final (SF) C$_{(0\text{-}3)}$VC structure, in word final (WF) position. Intervention specifically aimed at the accurate production of the phoneme /s/ when it is required for the manifestation of a) the morpheme of genitive case, feminine nouns in singular (GFS) for example [mɐˈmɐs] (mum's) and b) the morpheme of accusative case, masculine nouns in plural (AMP) for example [ˈɐdɾɛs] (men), [jɐˈtɾus] (doctors). There were 20 GFS and 20 AMP treated items. Six intervention sessions were designed. The complete set of treated items can be seen in Appendix 7.

6.3.3.3 Phase 3:

The third Phase of intervention focused on the production of /s/ in the consonant clusters /sk/ and /ks/ for phonological purposes, when it is included in the word stem. The phoneme was targeted in these consonant clusters in WI for example [ˈskɐlɐ] (ladder), [ˈksilo] (wood) and WW position for example [ðɐˈskɐlɐ] (teacher), [ˈtokso] (bow). There were 15 /sk/ WI and 10 /sk/ WW treated items, 10 /ks/ WI and 10 /ks/ WW treated items. Seven intervention sessions were designed. The complete set of treated items can be seen in

Appendix 8

6.3.3.4 Phase 4:

The fourth Phase of intervention focused on the production of /ks/ for morphological purposes, when it is used as a suffix for the manifestation of simple past tense. The phoneme was targeted in the final syllable, in syllable initial position for example [ˈfonɐksɛ] (shouted). There were 12 treated items for /ks/ used as a past tense morpheme. Five intervention Phases were designed. The complete set of treated items can be seen in Appendix 9.

6.3.4 Procedure and materials

6.3.4.1 Macro-assessment

In order to ensure that children met the third participant selection criterion, the two children were assessed with the complete test battery (described in Chapter 3) before the beginning and after the completion of the intervention programme. On each occasion, this took place over two or three assessment sessions 30 – 45 minutes long. The number and length of assessment sessions depended on each participant's pace at completing the assessment tasks.

6.3.4.2 Micro-assessment

Repeated probe assessments using picture naming were carried out pre and post the whole intervention and upon completion of each intervention Phase. In the latter case, they were carried out at the beginning of the next speech therapy intervention session. A picture-naming task was used to assess:

a. Therapy-targeted treated items: for each of the intervention goals, three of the treated items, were selected to function as probes, for example, [ˈskɐlɐ] (ladder) was selected as a treated item for the target /sk/ in WI position. Treated stimuli were used to evaluate the outcome of intervention on items that are directly targeted in intervention.
b. Therapy-targeted untreated items: for each of the intervention goals, three items, not directly targeted in intervention, were selected to function as probes; for example, [biˈskoto] (biscuit) was selected as an untreated item for the target /sk/ in WW position. Matched untreated stimuli were used to evaluate across-item generalization, i.e. on items that are not directly targeted in intervention
c. Not targeted in therapy – control items: For each of the intervention goals, comparable items were selected as controls to observe any possible generalization of intervention. For example, corresponding to the consonant cluster /sk/ that was targeted in intervention, words with cluster /st/, which was not targeted in intervention, were used as probes. Similarly, corresponding to the morpheme for genitive case feminine singular (GFS), the morpheme for the nominative case of feminine plural (NFP) that requires the same phoneme in SFWF position was targeted.

d. Not targeted in therapy, more distinctive items: For each intervention goal, i.e. phonological or morphological, items generating interest in the same domain, but sufficiently different from those included in intervention were selected to observe the overall development of skills over time. For example, corresponding to /s/ clusters that were targeted in intervention, words beginning with /ɾ/ clusters were used as probes. These stimuli were used to evaluate any global changes in the speech processing system. If a child succeeds on treated and untreated items, but not on these more distinctive items it would suggest that change observed can be attributed to intervention and not maturation. Alternatively, if a child does generalise to these more distinctive items it would suggest changes in the basis of the speech processing system, affecting the overall performance of the child. Comparison of performance pre and post intervention during periods of no intervention delivery would suggest if any noticeable change may be attributed to maturation and not to intervention. The complete set of stimuli used in probe assessment can be seen in Appendix 10.

Probe assessments were performed pre- and post-intervention, and before the commencement of each Phase of intervention. Regardless of the Phase where each target was introduced, the same stimuli were used as micro evaluation in all probe assessments. The properties of treated items and related controls are briefly described in Table 6-1.

Table 6-1 Stimuli characteristics in probe assessment (number of items)

	Therapy Targeted Treated items	Therapy targeted Untreated items	Not targeted in therapy – control items	Not targeted more distinctive
phonology	/s/+vowel Word Initial(3)	/s/+vowel Word Initial (3)	/z/ +vowel Word Initial (3)	
	/s/+vowel Word Within (3)	/s/+vowel Word Within (3)	/z/+vowel Word Within (3)	
	/sk/ +vowel Word Initial (3)	/sk/ +vowel Word Initial (3)	/st/ +vowel Word Initial (3)	/t ɾ /+vowel Word Initial (3)
	/sk/+vowel Word Within (3)	/sk/+vowel Word Within (3)	/st/ +vowel Word Within (3)	/t ɾ /+vowel Word Within (3)
	/ks/+vowel Word Initial (3)	/s/+vowel Word Initial (3)		
	/ks/+vowel Word Within (3)	/s/+vowel Word Within (3)		
morphology	/ks/+vowel Word Within (3) (Past Tense)	/ks/ +vowel Word Within (3) (Past Tense)	/ps/+vowel Word Within (3) (Past Tense)	Passive voice 3rd person (3)
	/s/ Word Final (3) Genitive Feminine Singular	/s/ Word Final Genitive Feminine Singular (3)	/s/ Word Final Nominative Feminine Plural (3)	/~u/ (3) Genitive Neutral Singular
	/s/ Word Final (3) Accusative Masculine Plural	/s/ / Word Final (3) Accusative Masculine Plural	/s/ Word Final (3) Nominative Masculine Plural	/~on/ (3) Masculine genitive plural

6.3.4.3 Intervention

A four-Phase intervention plan with predefined activities was designed from the outset. Each child received speech therapy sessions for 45 minutes twice a week for three months (24 sessions). An intervention programme using standard SLT activities for the production of /s/ in phonological and morphological contexts was carried out. Care was taken to include activities addressing all levels of difficulty that could possibly hinder the realization of /s/ in the participants' spontaneous speech.

Principles of traditional articulation therapy (Van Riper & Emerick, 1984) were adopted for intervention planning, targets being graded from simpler to more complex structures. For example with regard to phonological elements of the speech, accurate production of /s/ was targeted in the word stem in CV phonotactic structures in intervention Phase 1 (Appendix 11) and in CCV structures in intervention Phase 3 (Appendix 13). Similarly, with regard to morphological elements, accurate production of /s/ was targeted in VC phonotactic structures in the word ending in intervention Phase 2 (Appendix 12) and CCV structures in intervention Phase 4 (Appendix 14). Moreover, at the beginning of each intervention Phase accurate production is targeted at the syllabic level, then at the word level and in latter sessions at sentence level. In every phase of intervention a model was given to the child to imitate in the first session (see for example Appendix 15 session 1, 3rd activity), whereas in subsequent sessions spontaneous production of targets was requested (see for example Appendix 16 session 2, 2nd activity).

However, psycholinguistics formed the main theoretical basis for planning the current intervention. From this psycholinguistic perspective, the change from imitating words to spontaneous naming is interpreted as a change on the requirements for access to stored representations (see for example how the procedure for the production of the same targets changes between phase 1, session 1 (3rd activity) to phase 1, session 2 (2nd activity) and how it is used for the spontaneous production of morphemes in context (see for example Appendix 17phase 2, session 3, 3rd activity).

Adopting a psycholinguistic framework, the focus was not only on production but also on the input processing of phonological and morphological components, in tasks tapping auditory discrimination and the accuracy of representations. Auditory discrimination activities were devised both for targets of phonological interest and for targets of morphological interest. In auditory discrimination activities the child was asked to decide whether a pair of words heard were the same or different. When the focus was on phonological elements, some pairs were identical i.e. accurate productions of a target word, whereas others were different i.e. one being an accurate production of a target word and the other an inaccurate production with /s/ substituted by the child's own erroneous pronunciation. When the focus was on morphological elements, some pairs were identical i.e. the same morphemes were used and some others were different i.e. different morphemes were used (see for example Appendix 17 phase 2, session 3, 1st activity). In mispronunciation detection activities the child would see a picture in order to decide whether what was heard was accurate or not. Again, when the focus was on phonological elements some of the stimuli given were accurate productions for the target, whereas some others were inaccurate productions with /s/ substituted by the child's own erroneous pronunciation. When the focus was on morphological elements, some morphemes used would be accurate and some others inaccurate for the target.

Materials commonly used during speech therapy sessions with children of this age were used. Activities included:

- colourful pictures, either printed or presented using a lap-top computer via PowerPoint presentations for the children to name
- pairs of pictures that are phonologically or morphologically similar for children to identify which they have heard
- auditory discrimination tasks

Each child followed the therapeutic activities at their own pace, for as many times as needed to reach the criterion of success in a particular activity. The plan of the specific objectives and activities per session for each intervention Phase can be seen in Appendix 11-1. A detailed record of each child's performance at each intervention session was kept, including accuracy at each task, facilitators and reinforcements used during the session.

6.4 Results: Harry

Harry's performance on repeated probe assessments for treated items, untreated items and not targeted controls across intervention Phases can be seen in Table 6-2.

Table 6-2 Harry's performance on probe assessment across intervention Phases

	2 months pre	Pre	Phase 1	Phase 2	Phase 3	Phase 4	2 months post
Phase 1: Phonological /s/ in CV word initial and word within targets							
Targets treated /s/	0	0	4	0	3	5	4
Targets untreated /s/	0	0	1	0	5	4	3
Not targeted controls /z/	0	0	0	0	0	0	0
Phase 2: Morphological /s/ GFS, AMP							
Targets treated /s/ SFWF GFS, AMP	0	0	0	6	4	5	0
Targets untreated /s/ SFWF GFS, AMP	0	0	0	6	6	6	0
Not targeted controls /s/ SFWF AFP	0	0	0	6	6	6	0
Distinctive controls /n/SFWF Genitive Plural	6	6	6	6	6	6	6
Phase 3: Phonological /s/clusters in word initial and word within targets							
Targets treated /sk/	0	0	3	1	5	5	6
Targets untreated /sk/	0	0	1	1	1	6	6
Not targeted controls /st/	0	0	0	0	3	2	2
Targets treated /ks/	0	0	0	0	3	4	4
Targets untreated /ks/	0	0	0	0	1	5	3
Not targeted controls /ps/	0	0	0	0	0	0	0
Distinctive controls /tr/	0	1	3	3	3	4	4
Phase 4: Morphological /ks/ simple past morphemes							
Targets treated /ks/ past	0	0	0	0	0	3	1
Targets untreated /ks/ past	0	0	0	0	0	2	1
Not targeted controls /ps/ past	0	0	0	0	0	0	0
Distinctive controls passive voice	1	1	3	2	2	3	3

(Performance on items that have been targeted in intervention is enclosed in shaded boxes)

6.4.1 Performance on probe assessment

6.4.1.1 Probe assessment prior to intervention

Probe assessment two months prior and immediately prior to the initiation of speech therapy sessions revealed production of the target phoneme was inaccurate both in CV structure and in consonant clusters. There was restricted production of distinctive controls i.e. /tɾ/ 1/6 accuracy, passive voice 1/3 accuracy. There was no change in the two months between the two pre-intervention assessments.

6.4.1.2 Probe assessment across phases of intervention

Intervention Phase 1 targeted the production of /s/ in CV structures in word initial and word within position. Probe assessment upon completion of Phase 1 revealed accurate production of 4/6 therapy targeted – treated items, as well as accurate production of 1/6 therapy targeted – untreated items. As for not targeted control items with /z/ in CV structure in word initial and word within position, there were no accurate productions (0/6). It is worth noting that a score of 4/12 accurate productions of /s/ in /sk/ cluster, which had not yet been targeted in intervention during Phase 1, was obtained. It seems that once Harry was able to produce /s/ there was partial generalization to other phonotactic structures. As for the distinctive controls, Harry scored 3/6 on /tɾ/ cluster and 3/3 on passive voice production. Performance on Phase 1 targets in phases 2-4 is described separately upon completion of each phase in subsequent sections.

Intervention Phase 2 targeted the production of /s/ in syllable final, word final position as a morphophoneme required for the production of the genitive case of feminine nous in singular number and the accusative case of masculine nouns in plural. Probe assessment upon completion of Phase 2 revealed accurate production of therapy targeted – treated items (6/6), therapy targeted – untreated items (6/6) as well as accurate production of the non – targeted control items of accusative case, feminine nouns in plural. It seems that when therapy follows a morphological direction, Harry was able to generalize to the appropriate production of other morphemes that require /s/. There was no accurate production of /s/ plus vowel items targeted in therapy in Phase 1. However, there was a score of 2/12 accurate productions of /s/ in /sk/ cluster, which had not yet been targeted in intervention.

Intervention Phase 3 targeted the production of /s/ in CCV structures i.e. consonant clusters /sk/ and /ks/. Probe assessment upon completion of Phase 3 revealed accurate production (5/6) of therapy targeted – treated items and accurate production (1/6) of therapy targeted – untreated items for /sk/ clusters. Not targeted controls /st/ were produced accurately 3/6 times. For the second cluster /ks/ therapy targeted treated items were produced accurately 4/6 times whereas therapy targeted untreated items were produced accurately 5/6 times. There was no accurate production of not targeted controls /ps/ clusters in any word position. At the end of Phase 3 Harry was able to produce /ks/ as a cluster accurately with a score of 3/6 in word initial and word within position; however, there was no accurate production of the same cluster in word within position when used as a morpheme of past tense. It seems that morpheme production was not improved following phonologically targeted intervention.

Intervention Phase 4 targeted the production of /ks/ as a morphophoneme indicative of the past tense. Immediately post intervention i.e. upon completion of Phase 4 the target was accurately produced in 3/3 treated items and 2/3 untreated items. However, the production of not targeted controls that require the production of /ps/ as a morpheme of past tense remained inaccurate (0/3). Upon completion of phase 4 there was an improvement on performance accuracy on untreated items for consonant clusters which had been the focus of intervention phase 3. Improvement was noticed on untreated items containing /sk/ (from 1/6 to 6/6) and /ks/ clusters (from 1/6 to 5/6). It seems that there were some gains in phonological targets following morphologically targeted intervention.

6.4.1.3 Probe assessment two months post intervention

In order to evaluate maintenance of intervention outcome Harry's performance on probe assessments for treated items, untreated items and not targeted controls was assessed two months upon completion of intervention. During this time the child was not attending speech therapy sessions. Performance can be seen in Table 6-2.

Harry retained the ability to produce accurately /s/ in syllable initial, word initial and word within position, both for treated and untreated items. He was also capable of producing consonant clusters, those targeted in intervention i.e. /sk/ and /ks/ as well as untreated /st/. He did not produce accurately /s/ in word final position, when required for the manifestation of morphemes. He produced /ks/ as a morpheme of simple past accurately 1/3 times for treated items and 1/3 times for untreated items.

6.4.1.4 Comparison of performance on probe assessment pre and post intervention

In order to investigate the effectiveness of intervention a comparison of performance accuracy on repeated probe assessments was done for the total of treated, untreated and control items. Comparison of performance concerns time points when all or none of the treated items had been addressed in intervention i.e. immediately before and immediately after the provision of intervention, as well as at intervals without intervention, two months before the initiation of speech therapy and two months following its completion. Performance during intervention phases is not included given that the number of treated items altered from one phase to another. The analysis is based on the total number of items that were targeted, regardless of the intervention phase in which they were addressed. Correspondingly, performance is analyzed for the total number of untreated and control items. Harry's scores in repeated probe assessment for treated, untreated and control items at each assessment point pre and post intervention are presented in Table 6-3.

Table 6-3 Harry's performance in probe assessment at pre and post intervention time points

	Treated items				Untreated items				Control items			
	Two months pre	Immediately pre	Immediately Post	Two months post	Two months pre	Immediately pre	Immediately Post	Two months post	Two months pre	Immediately pre	Immediately Post	Two months post
Correct	0	0	22	15	0	0	24	13	0	0	8	2
Incorrect	27	27	5	12	27	27	3	14	27	27	19	25
Total	27	27	27	27	27	27	27	27	27	27	27	27

Treated items

A Cochran's Q test indicated a statistically significant difference between scores for treated items at the four points of assessment (Cochran's Q = 54.33, df = 3, p < .001). Therefore, pairwise comparison of performance accuracy was performed using two-tailed McNemar tests[4]. These indicated a significant difference between performance accuracy for treated items immediately pre-intervention and immediately post-intervention (p < .001); between performance pre-intervention and at follow-up two months post intervention (p < .001); between performance immediately post intervention and at follow up two months post intervention (p= .016). Performance accuracy for treated items on probe assessment post intervention was significantly better than performance pre intervention; however, two months post intervention Harry scored significantly lower than immediately post-intervention, indicating that the effect of intervention on treated items was not maintained fully. Nevertheless, some effect of intervention was maintained since his score 2 months post intervention remained significantly higher than his score prior to the start of the intervention.

Untreated items

Again, a Cochran's Q test indicated a statistically significant difference between scores for untreated items at the four points of assessment (Cochran's Q = 56.86, df =3, p < .001). Therefore, pairwise comparison of performance accuracy was performed using two-tailed McNemar tests. These indicated a significant difference between performance accuracy for untreated items immediately pre-intervention and immediately post-intervention (p < .001); between performance pre-intervention and at follow-up two months post intervention (p < .001); between performance immediately post intervention and at follow up two months post intervention (p= .001). Performance accuracy for untreated items on probe assessment post intervention was significantly better than performance pre intervention; however two months post intervention Harry scored significantly lower than immediately post-intervention, indicating that the effect of intervention on untreated items was not maintained fully. Nevertheless, some effect of intervention was maintained since his score 2 months post intervention remained significantly higher than his score prior to the start of the intervention.

[4] In order to apply a Bonferroni correction, the original p=.05 value used to test null hypothesis was divided by the number of pairwise comparisons (possible comparisons 6, new p value=.008). A value of p >.008 indicates a difference that would not maintain significance under Bonferroni correction

Control items

A Cochran's Q test again indicated a statistically significant difference between the scores for control items at the four points of assessment (Cochran's Q = 19.85, df =3, p < .001). Therefore, pairwise comparison of performance accuracy was performed using two-tailed McNemar tests. These indicated a significant difference between performance accuracy for control items immediately pre-intervention and immediately post-intervention (p =.008); between performance accuracy immediately post intervention and at follow up two months post intervention (p=.031*)[5]; no significant difference was found between performance pre-intervention and at follow-up two months post intervention (p =.500). Performance accuracy on probe assessment immediately post intervention for control items was significantly better than performance pre intervention; however, two months post intervention Harry scored significantly lower than immediately post-intervention, indicating that the effect of intervention on control items was not maintained fully. In this case, there was no lasting effect of intervention since his score 2 months post intervention was not significantly higher than his score prior to the start of the intervention.

There was significant change in performance accuracy on specific word positions and clusters that had been directly targeted in intervention. Intervention outcome for treated items and similar untreated items was preserved two months post the end of the intervention program. Upon completion of the intervention phases there was some generalization to control items that had not been directly targeted; however, this was not preserved after a period of two months without intervention.

6.4.2 Performance on baseline assessment

Performance on baseline assessment is compared to data from peers of the same age participating in the normative study i.e. group 1 at T3 when the children were aged 4; 0 – 4; 5. Harry's performance can be seen in Table 6-4. Performance on tests found to be one and a half standard deviation below the performance of peers is highlighted with red colour and performance within the expected range age range is highlighted with green. With regard to output production tasks the scoring methods for the whole word accuracy and Percentage of Consonants Correct were followed as in the normative study.

[5] results marked with an asterisk would not maintain significance under Bonferroni correction

Table 6-4 Harry's performance on baseline assessment compared to 4; 0 – 4; 5 years old children on the normative study

	Task	Possible total	Mean	Standard Deviation	=-1.5 Standard Deviation	2 months pre	Pre	Post	2 months post
Language tasks	DVIQC	31	21.00	3.63	15.55	20	21	22	26
	DVIQP	24	15.06	2.98	10.60	14	14	14	14
	DVIQ SR	48	45.73	2.34	42.22	35	36	39	42
	DVIQCexp	23	18.25	2.29	14.81	14	14	16	16
	DVIQPexp	26	16.19	3.54	10.87	8	9	12	20
	ActionGr	66	38.73	9.18	24.97	32	32	36	30
	ActionInf	50	25.21	4.98	17.74	22	20	16	14
	BusInf	58	13.60	5.07	6.00	7	6	7	6
	BusMLU		10.52	3.06	5.93	6.0	6.0	6.4	6.4
	BusSub		2.47	1.96	-0.47	3	3	3	4
	Vocab	50	22.25	7.92	10.37	13	11	12	13
Input tasks (performance above chance at	NWAudDP	30 (23)	23.50	3.27	18.60	20	21	27	24
	NWAudDM	30 (23)	25.88	3.07	21.26	22	23	26	28
	RWAudDP	30 (23)	24.87	2.47	21.15	19	19	21	25
	RWAudDM	30 (23)	26.31	2.91	21.94	17	16	24	27
	RWPicCh	30 (17)	21.07	3.83	15.33	19	17	24	24
	MisPrJ	30 (23)	25.27	2.46	21.57	20	21	25	28
Output tasks	Naming	up to 50	24.19	11.93	6.29	4	6	15	15
	RWRepP	30	24.60	5.95	15.68	16	16	19	21
	RWRepM	30	22.93	8.19	10.65	5	7	18	8
	RWPol s	21	11.40	7.34	0.39	3	4	7	9
	NWRepP	30	22.53	5.96	13.59	17	18	20	24
	NWRepM	30	21.73	7.96	9.79	6	7	16	9
	NWPol s	21	10.07	6.51	0.30	2	3	5	7
	Naming	100%	89.84	12.07	71.73	61.4	65.3	85.3	86.1
	RWRepP	100%	92.47	9.21	78.65	79.0	80.0	85.7	88.3
	RWRepM	100%	93.23	8.57	80.38	76.3	77.9	87.8	81.7
	RWPol s	100%	87.57	12.67	68.56	66.7	68.0	81.1	86.5
	NWRepP	100%	89.44	9.12	75.76	77.2	79.2	91.0	87.0
	NWRepM	100%	89.44	11.47	72.23	68.4	71.3	83.2	74.3
	NWPol s	100%	86.01	13.30	66.06	65.7	65.7	82.9	83.8
STM	MemoryW	108	39.67	14.80	17.47	20	18	18	22
	MemoryO	28	9.93	2.71	5.87	6.0	5.0	5.0	6.0
PA	Segm	68	36.40	5.70	27.84	20	20	29	34
	Blend	10	7.90	1.48	5.68	4.5	4.5	5.0	5.0

Performance on tests found to be one and a half standard deviation below the performance of peers is highlighted with red colour and performance within the expected age range is highlighted with green.

Baseline assessment with the complete test battery used in the normative study indicated that in the two months prior to the initiation of speech therapy sessions there was no remarkable change in speech and language skills.

According to DVIQ Harry had language skills within the expected range, as performance on DVIQC and DVIQP approached mean performance of age matched controls. However, performance on language comprehension and production as assessed with experimental tasks and DVIQSR indicate language performance that fell below 1.5 standard deviation of age matched peers. Elicited language production and narrative skills were age appropriate as indicated by grammar score, information score, MLU score and production of subordinate clauses.

Vocabulary knowledge was within expected range for his age as indicated by performance on the word finding task.

Turning to speech processing, performance on all tasks tapping input abilities was below the mean performance of age matched controls. Mean performance of typically developing children (group 1 at T3) was above chance level on all input tasks (score indicating performance above chance is presented in brackets in the column of possible total). Harry performed below the level of chance in all tasks. His performance on RWAudD tasks, both for phonological and morphological items and Mispronunciation detection met the criterion of one and a half standard deviation below the mean.

Performance on all tasks tapping output abilities, when scored for PCC accuracy, met the criterion of one and a half standard deviation below the mean, except of RWRepP and NWRepP that approached but did not meet criterion. Speech production difficulties included substitution of /s/ with [ɬ]. Harry was not able to produce the target phoneme in lower level single phoneme, DDK production.

6.4.2.1 Comparison of performance on baseline tasks pre and post intervention

In order to investigate whether following intervention there is significant change on general speech and language abilities, a comparison of performance accuracy on baseline assessment tasks was done. Pre and post intervention performance was compared for tasks that two months pre intervention met the criterion of one and a half standard deviation below the mean performance of children of the same age (as shown in Table 6-4). Harry had not achieved the expected for his age level of development and on this ground it would be informative to investigate his performance on these tasks following intervention. These tasks were the input tasks of RWAudDPhon, RWAudDMor and MisprD and the output tasks of Naming, RWRepMor and RWRepPol scored for the PCC. In order to be directly comparable, data should be represented in a nominal scale.

6.4.2.2 Comparison of performance on input tasks

Harry's accuracy scores, for the input tasks being analysed can be seen in Table 6-5.

Table 6-5 Harry's performance in input tasks at pre and post intervention time points

	RWAudDPhon				RWAudDMor				MisprD			
	Two months pre	Immediately pre	Immediately Post	Two months post	Two months pre	Immediately pre	Immediately Post	Two months post	Two months pre	Immediately pre	Immediately Post	Two months post
Correct	19	19	21	25	17	16	24	27	20	21	25	28
Incorrect	11	11	9	5	13	14	6	3	10	9	5	2
Total	30	30	30	30	30	30	30	30	30	30	30	30

Real Word Auditory Discrimination Phonological (RWAudDPhon)

A Cochran's Q test indicated a statistically significant difference between scores for RWAudDPhon task at the four points of assessment (Cochran's Q=14.40, df=3, p=.002). Therefore, pairwise comparison of performance accuracy was performed using two-tailed McNemar tests. These indicated no significant difference between performance accuracy two months pre intervention and immediately pre-intervention (p=1.00); immediately pre intervention and immediately post intervention (p=.50); immediately post intervention and two months post intervention (p=.125). However, a statistically significant change was observed in RWAudDPhon task between performance accuracy immediately pre intervention and two months post intervention (p=.031*).

Real Word Auditory Discrimination Morphological (RWAudDMor)

A Cochran's Q test indicated a statistically significant difference between scores for RWAudDMor task at the four points of assessment (Cochran's Q=25.80, df=3, p<.001).

Therefore, pairwise comparison of performance accuracy was performed using two-tailed McNemar tests. These indicated no significant difference between performance accuracy two months pre intervention and immediately pre-intervention (p=1.00); immediately post intervention and two months post intervention (p=.250); a statistically significant change was observed in RWAudDMor task between performance accuracy immediately pre intervention and immediately post intervention (p=.008) as well as between performance accuracy immediately pre intervention and two months post intervention (p=.001). This indicates maintenance of effect upon two months without intervention.

Mispronunciation Detection (MisprD)

A Cochran's Q test indicated a statistically significant difference between scores for MisprD task at the four points of assessment (Cochran's Q=17.57, df=3, p=.001). Therefore, pairwise comparison of performance accuracy was performed using two-tailed McNemar tests. These indicated no significant difference between performance accuracy two months pre intervention and immediately pre-intervention (p=1.00); between performance accuracy immediately pre intervention and immediately post intervention (p=.125), between performance accuracy immediately post intervention and at follow up two months post intervention (p=.250). However, a statistically significant change was observed in MisprD task between performance accuracy immediately pre intervention and two months post intervention (p=.016*). Immediately post intervention performance accuracy in MisprD task did not meet criterion of -1.5 St. D. below the mean performance of children of the same age, despite the fact that there was not a statistically significant change in Harry's performance.

6.4.2.3 Comparison of performance on Output tasks

Harry's accuracy scores, for the output tasks analysed can be seen in Table 6-6. To enable the analysis of percentages, the decimal digits are rounded to integer value. If the fractional portion of number is 0.5 or greater, the argument is rounded to the next higher integer. If the fractional portion of number is less than 0.5, the argument is rounded to the next lower integer.

Table 6-6 Harry's performance in output tasks at pre and post intervention time points

	Naming PCC				RWRepMor PCC				RWRepPol PCC				NWRepMor PCC				NWRepPol PCC			
	Two months pre	Two months pre	Immediately pre	Immediately Post	Two months pre	Immediately pre	Immediately Post	Two months post	Two months pre	Immediately pre	Immediately Post	Two months post	Two months pre	Immediately pre	Immediately Post	Two months post	Two months pre	Immediately pre	Immediately Post	Two months post
Correct	61	65	85	86	76	78	88	82	67	70	81	87	68	71	83	74	66	66	83	84
Incorrect	39	35	15	14	24	22	12	18	33	30	19	13	32	29	17	26	34	34	17	16
Total	100				100				100				100				100			

Naming

A Cochran's Q test indicated a statistically significant difference between scores for Naming task scored for PCC at the four points of assessment (Cochran's Q = 65.02, df = 3, p< .001). Therefore, pairwise comparison of performance accuracy was performed using two-tailed McNemar tests. These indicated no significant difference between Naming PCC performance accuracy two months pre intervention and immediately pre-intervention (p= .125); between Naming PCC performance accuracy immediately post intervention and at follow up two months post intervention (p=1.0). A statistically significant difference in Naming accuracy scored for PCC was found between performance immediately pre intervention and immediately post intervention (p<.001). Compared to pre intervention performance, there was a statistically significant increase in Naming PCC accuracy post intervention that did not change at follow up two months post intervention.

Real Word Repetition Morphological (RWRepMor)

A Cochran's Q test indicated a statistically significant difference between scores for RWRepMor task scored for PCC at the four points of assessment (Cochran's Q = 25.20, df = 3, p< .001). Therefore, pairwise comparison of performance accuracy was performed using two-tailed McNemar tests. These indicated no significant difference between performance accuracy two months pre intervention and immediately pre-intervention (p=.500). A statistically significant change was observed in RWRepMor task scored for PCC between performance immediately pre intervention and immediately post intervention (p=.002); immediately post intervention and two months post intervention (p=.031*). Performance accuracy on RWRepMorPCC immediately post intervention was significantly better than performance accuracy pre intervention; there was not a significant difference immediately pre and two months post intervention (p=.125), indicating that upon completion of intervention performance accuracy decreased and there was no lasting effect of intervention on this measure.

Real Word Repetition Polysyllabic (RWRepPol)

A Cochran's Q test indicated a statistically significant difference between scores for RWRepPol task scored for PCC at the four points of assessment (Cochran's Q = 40.41, df = 3, p< .001). Therefore, pairwise comparison of performance accuracy was performed using two-tailed McNemar tests. These indicated no significant difference between performance accuracy two months pre intervention and immediately pre-intervention (p=.250). A statistically significant change was observed in RWRepPol task scored for PCC between performance immediately pre intervention and immediately post intervention (p=.001); immediately post intervention and two months post intervention (p=.031). Performance accuracy on RWRepPolPCC immediately post intervention was significantly better than performance accuracy pre intervention; at follow up two months post intervention there was again a significant change and performance accuracy further increased.

Nonword Repetition Morphological (NWRepMor)

A Cochran's Q test indicated a statistically significant difference between scores for NWRepMor task scored for PCC at the four points of assessment (Cochran's Q = 31.50, df = 3, p< .001). Therefore, pairwise comparison of performance accuracy was performed using two-tailed McNemar tests. These indicated no significant difference between performance accuracy two months pre intervention and immediately pre-intervention (p=.250). A statistically significant change was observed in NWRepMor task scored for PCC between performance immediately pre intervention and immediately post intervention (p<.001);

immediately post intervention and two months post intervention (p=.004). Performance accuracy on NWRepMorPCC immediately post intervention was significantly better than performance accuracy pre intervention; however two months post intervention there was a significant change and performance accuracy decreased. There was no significant difference between performance accuracy on NWRepMorPCC immediately pre intervention and 2 months post intervention (p=.250), indicating there was no lasting effect of intervention on this measure.

Nonword Repetition Polysyllabic (NWRepPol)

A Cochran's Q test indicated a statistically significant difference between scores for NWRepPol task scored for PCC at the four points of assessment (Cochran's Q = 51.85, df = 3, p< .001). Therefore, pairwise comparison of performance accuracy was performed using two-tailed McNemar tests. These indicated no significant difference between performance accuracy two months pre intervention and immediately pre-intervention (p=1.00). A statistically significant change was observed in NWRepPol task scored for PCC between performance immediately pre intervention and immediately post intervention (p<.001); no change was observed immediately post intervention and two months post intervention (p=1.00). Performance accuracy on NWRepPolPCC immediately post intervention was significantly better than performance accuracy pre intervention; at follow up two months post intervention performance accuracy was maintained.

6.5 Results: Anthi

Anthi's performance on repeated probe assessments for treated items, untreated items and not targeted controls across intervention Phases can be seen in Table 6-7. Performance on items that have been targeted in intervention is enclosed in shaded boxes.

Table 6-7 Anthi's performance on probe assessment across intervention Phases

	2 months pre	Pre	Phase 1	Phase 2	Phase 3	Phase 4	Phase 4 2nd	2 months post
Phase 1: Phonological /s/ in CV word initial and word within targets								
Targets treated /s/	0	0	6	0	6	0	6	0
Targets untreated /s/	0	0	5	0	5	0	6	0
Not targeted controls /z/	0	0	6	0	5	0	6	0
Phase 2: Morphological /s/ GFS, AMP								
Targets treated /s/ SFWF GFS, AMP	0	0	6	0	0	0	6	0
Targets untreated /s/ SFWF GFS, AMP	0	0	6	0	0	0	6	0
Not targeted controls /s/ SFWF AFP	0	0	6	0	0	0	6	0
Distinctive controls /n/SFWF Genitive Plural	6	6	6	6	6	6	6	6
Phase 3: Phonological /s/clusters in word initial and word within targets								
Targets treated /sk/	0	0	5	0	6	0	6	0
Targets untreated /sk/	0	0	4	0	5	0	6	0
Not targeted controls /st/	0	0	6	0	5	0	6	0
Targets treated /ks/	0	0	6	0	5	0	2	0
Targets untreated /ks/	0	0	6	0	5	0	1	0
Not targeted controls /ps/	0	0	6	0	0	0	6	0
Distinctive controls /tr/	6	6	6	6	6	6	6	6
Phase 4: Morphological /ks/ simple past morphemes								
Targets treated /ks/ past	0	0	3	0	1	0	3	0
Targets untreated /ks/ past	0	0	2	0	1	0	3	0
Not targeted controls /ps/ past	0	0	3	0	0	0	3	0
Distinctive controls passive voice	3	3	3	3	3	3	3	3

(Performance on items that have been targeted in intervention is enclosed in shaded boxes)

6.5.1 Performance on probe assessment

6.5.1.1 Probe assessment prior to intervention

Probe assessment two months prior and immediately prior to the initiation of speech therapy sessions revealed there was no accurate production of the target phoneme /s/ in CV structure nor in consonant clusters or in morphological context. Control phoneme /z/ was also substituted with /ð/. Nevertheless distinctive controls were accurately produced.

6.5.1.2 Probe assessment across phases of intervention

Intervention Phase 1 targeted the production of /s/ in CV structures in word initial and within word position. Anthi's performance on Phase 1 treated items, across intervention Phases, can be seen in Table 6-7. Probe assessment upon completion of Phase 1 revealed accurate production of treated items, untreated items and not targeted controls. It is worth noting that during probe assessment Anthi was very concentrated and careful with articulation movements, keeping her teeth firmly closed, occasionally prolonging the duration of the target phoneme. In some cases just after the correct production of a target word, Anthi made a comment about it and in this short phrase of spontaneous speech, production of the target word was incorrect. However, it seems that Anthi was able to use the principles for the correct production of /s/ in untreated items in single word naming task.

Intervention Phase 2 targeted the production of /s/ in syllable final, word final position as a morphophoneme required for the production of the genitive case of feminine nouns in singular number and the accusative case of masculine nouns in plural. Anthi's performance on Phase 2 treated items across intervention phases can be seen in Table 6-7. Probe assessment upon completion of Phase 2 revealed that there were no accurate productions of treated items, untreated items and not targeted controls. However items treated in Phase 2 were accurately produced upon completion of phase 1 as well as upon completion of phase 4. It is worth mentioning at this point that at the beginning of the assessment Anthi asked "should I say the words with teeth closed?" and the clarification that she was given was "say the words as you think it will be correct". It seems that Anthi was concerned about the proper use of articulators at the lower level of motor execution.

Intervention Phase 3 targeted the production of /s/ in CCV structures i.e. consonant clusters /sk/ and /ks/. Anthi's performance on Phase 3 treated items across intervention phases can be seen in Table 6-7. Probe assessment upon completion of Phase 3 revealed accurate production of therapy targeted treated and untreated items for /sk/ and /ks/ clusters and not targeted controls /st/ but inaccurate production of not targeted controls /ps/. In addition /s/ was accurately produced in CV structure in therapy targeted treated and untreated items as well as in not targeted controls /z/. There were no accurate productions of /s/ in word final position required within morphological context, as it had been targeted in Phase 2. However, upon completion of Phase 3 that targeted the production of /ks/ in the word stem, Anthi was able to produce accurately the same cluster in 2/6 items as a past tense suffix for verbs, which had not yet been targeted. It seems that once the phonological target was set in intervention, some generalization occurred in the direction of appropriate production of the same cluster in morphemes.

Intervention Phase 4 targeted the production of /ks/ as a morphophoneme indicative of the simple past tense. Anthi's performance on Phase 4 treated items across intervention phases can be seen in Table 6-7. Immediately post intervention i.e. upon completion of Phase 4 there were no accurate productions.

The dialogue that followed immediately upon completion of the probe assessment is particularly revealing as regards Anthi's approach to the task.

Anthi: with teeth open, not closed, huh?

με ανοιχτά δόντια, όχι με κλειστά, ε;

Researcher: as you think it is right

όπως νομίζεις ότι είναι σωστό

Anthi: I said it correct?

το είπα καλά;

Researcher: what do you think?

τι νομίζεις;

Anthi: mmm (*looking very puzzled*).

Researcher: do you want to say it once again?

θέλεις να τα πεις άλλη μια φορά;

Thereafter the probe assessment was repeated. In her second attempt Anthi made a self-correction on the first item [θ...ˈsupɐ] (soup) and then she produced all the treated targets, untreated targets and not targeted controls accurately with the exception of /ks/ that was produced accurately 2/6 in treated targets and 1/6 in untreated targets. These results are shown in Table 6-7 as *Phase 4: 2nd*.

Even though it was not required by the procedure, once Anthi completed her second attempt on probe assessment, she was asked to complete the DDK task that is included in the complete battery used in the baseline assessment. She was asked to say repeated syllables with /s/ followed by a vowel, in order to assess her lower level motor execution skills for the production of the target phoneme. When there was eye contact with the therapist the production of these syllables was correct whereas when there was no eye contact with the therapist, production was incorrect. It seems that lower level output production i.e. articulatory-motor execution skills were adequate for the accurate production of the target phoneme. It is possible that inaccurate production was a result of top down processing. It is suggested that when the child had eye contact with the therapist, she was concentrated on the task, she consciously controlled articulators' movement and she performed accurately. When she did not have eye contact, she was less concentrated and top down influence of inaccurate motor programs influence her performance.

6.5.1.3 Probe assessment two months post intervention

Two months after completion of the intervention programme, post intervention assessment coincided with the onset of dentition change from temporary to permanent. Anthi was missing the two central teeth in the lower jaw, thus the structure of the articulators had changed since the period of intervention delivery. Furthermore she had a mild cold but according to the ENT examination she had normal hearing. In probe assessment two months post intervention there were no accurate productions of any target.

6.5.1.4 Comparison of performance on probe assessment pre and post intervention

In order to investigate the effectiveness of intervention a comparison of performance accuracy on repeated probe assessments was carried out for the total of treated, untreated and control items. Comparison of performance concerns time points when all or none of the treated items had been addressed in intervention i.e. immediately before and immediately after the provision of intervention (the second attempt), as well as at intervals without intervention, two months before the initiation of speech therapy and two months following its completion. The analysis is based on the total number of items that were targeted, regardless of the intervention phase in which they were addressed. Correspondingly performance is analyzed for the total number of untreated and control items. Anthi's scores, in repeated probe assessment for the total number of treated, untreated and control items at each assessment point pre and post intervention are presented in Table 6-8. Performance during intervention phases is not included given that the number of treated items altered from one phase to another.

Table 6-8 Anthi's performance in probe assessment at pre and post intervention time points

	Treated items				Untreated items				Control items			
	Two months pre	Immediately pre	Immediately Post	Two months post	Two months pre	Immediately pre	Immediately Post	Two months post	Two months pre	Immediately pre	Immediately Post	Two months post
Correct	0	0	23	0	0	0	22	0	0	0	27	0
Incorrect	27	27	4	27	27	27	5	27	27	27	0	27
Total	27	27	27	27	27	27	27	27	27	27	27	27

Treated items

A Cochran's Q test indicated a statistically significant difference between scores for treated items at the four points of assessment (Cochran's Q = 69.00, df = 3, $p < .001$). Therefore, pairwise comparison of performance accuracy was performed using two-tailed McNemar tests. Comparison indicated significant difference between performance accuracy for treated items immediately pre-intervention and immediately post-intervention ($p < .001$). This was the only possible comparison, for the reason that the variable was constant two months pre intervention, immediately pre intervention and two months post intervention thus the McNemar test could not be performed. Performance accuracy for treated items on probe assessment post intervention was significantly better than performance pre intervention.

Untreated items

Again, a Cochran's Q test indicated a statistically significant difference between scores for untreated items at the four points of assessment (Cochran's Q = 66.00, df = 3, $p < .001$). Therefore, pairwise comparison of performance accuracy was performed using two-tailed McNemar tests. Comparison indicated significant difference between performance accuracy for untreated items immediately pre-intervention and immediately post-intervention ($p < .001$). This was the only possible comparison, for the reason that the variable was constant two months pre intervention, immediately pre intervention and two months post intervention thus the McNemar test could not be performed. Performance accuracy for untreated items on probe assessment post intervention was significantly better than performance pre intervention.

Control items

A Cochran's Q test again indicated a statistically significant difference between the scores for control items at the four points of assessment (Cochran's Q = 81, df= 3, $p < .001$). Therefore, pairwise comparison of performance accuracy was performed using two-tailed McNemar tests. Comparison indicated significant difference between performance accuracy for control items immediately pre-intervention and immediately post-intervention ($p < .001$). This was the only possible comparison, for the reason that the variable was constant two months pre intervention, immediately pre intervention and two months post intervention thus the McNemar test could not be performed. Performance accuracy for treated items on probe assessment post intervention was significantly better than performance pre intervention.

6.5.2 Performance on baseline assessment

Performance on baseline assessment is compared to data from peers of the same age participating in the normative study i.e. group 2 at T3 when the children were aged 5; 6 – 6; 0. Anthi's performance on baseline assessment compared to 5;6-6;0 years old children can be seen in Table 6-9. Performance on tests found to be one and a half standard deviation below the performance of peers is highlighted with red colour and performance within the expected age range is highlighted with green. With regard to output production tasks, the scoring methods for whole word accuracy and Percentage of Consonants Correct were followed as in the normative study.

Table 6-9 Anthi's performance on baseline assessment compared to 5;6 – 6;0 years old children on the normative study

	Task	Possible total	Controls Mean	Standard Deviation	≥-1,5 Standard Deviation	2 months pre	Imm pre	Imm post	2 months post
Language tasks	DVIQC	31	26.00	2.17	22.75	20	22	25	27
	DVIQP	24	16.11	2.33	12.61	11	14	15	19
	DVIQ SR	48	45.22	5.11	37.56	38	40	47	48
	DVIQCexp	23	20.72	1.99	17.73	9	17	18	22
	DVIQPexp	26	20.16	2.65	16.18	13	17	22	23
	ActionGr	66	47.33	5.37	39.28	30	24	24	36
	ActionInf	50	33.22	6.11	24.05	25	24	31	24
	BusInf	58	26.11	7.68	14.60	13	14	30	26
	BusMLU		13.47	2.66	9.48	8	10.8	10	12.8
	BusSub		5.11	2.63	1.16	2	4	5	5
	Vocab	50	33.68	5.51	25.42	20	20	28	29
Input tasks (performance above chance at p=.05)	NWAudDP	30	26.06	2.75	21.92	23	22	25	25
	NWAudDM	30	28.00	2.00	25.00	23	23	23	25
	RWAudDP	30	27.39	1.94	24.47	25	23	24	23
	RWAudDM	30	27.44	2.87	23.13	23	28	24	25
	RWPicCh	30	25.39	2.55	21.57	20	22	22	25
	MisPrJ	30	27.17	1.89	24.34	19	21	24	27
Output tasks	Naming	up to 50	35.11	8.35	22.59	20	25	32	24
	RWRepP	30	27.00	3.66	21.51	18	20	20	21
	RWRepM	30	26.11	5.95	17.19	10	11	12	11
	RWPol s	21	17.00	5.98	8.03	6	6	7	6
	NWRepP	30	25.67	4.46	18.98	14	17	22	18
	NWRepM	30	24.37	6.44	14.71	3	6	9	9
	NWPol s	21	15.33	6.15	6.10	0	4	6	6
	Naming	100%	94.11	5.30	86.15	87.18	89.6	97.5	89.9
	RWRepP	100%	96.10	4.76	88.97	84.4	87.0	87.0	88.3
	RWRepM	100%	96.48	5.60	88.08	76.3	83.2	84.7	84.0
	RWPol s	100%	95.02	7.59	83.64	80.2	82.9	85.6	84.7
	NWRepP	100%	95.08	4.85	87.80	77.9	84.4	90.9	84.4
	NWRepM	100%	92.85	8.61	79.94	71.4	74.4	76.2	76.2
	NWPol s	100%	92.98	9.20	79.18	69.5	72.9	86.5	86.5
STM	MemoryW	108	48.00	11.47	30.80	17	20	26	44
	MemoryO	28	12.61	2.23	9.27	5	6	9	11
PA	Segm	68	44.33	10.50	28.58	33	33	33	34
	Blend	10	9.19	1.06	7.61	9	9	10	10

Performance on tests found to be one and a half standard deviation below the performance of peers is highlighted with red colour and performance within the expected age range is highlighted with green.

Baseline assessment with the complete test battery used in the normative study indicated that during the two months prior to the initiation of speech therapy sessions performance on the majority of tasks (21/35) remained 1.5 Standard Deviation below the mean as can be seen in Table 6-9, columns 6 and 7.

Anthi had language skills below the expected range for her age, as can be seen in Table 6-9. Performance on language comprehension and production tasks, as assessed with DVIQ C and DVIQ P respectively, two months prior to the initiation of therapy met the criterion of one and a half standard deviation below the mean of age matched controls. Performance on assessment tasks of vocabulary production, elicited language production and information provided in narrative was significantly lower than peers' performance.

Turning to speech processing, performance on most input tasks, including those that tap stored lexical representations, fell one and a half standard deviation below the average performance of age matched peers. Performance on NWAudDP and RWAudDP was well below the mean, approaching the criterion of –1.5 Standard Deviations. Naming accuracy scored for PCC was well below the mean, approaching the criterion of –1.5 Standard Deviations. Performance on RW and NW Repetition tasks shows that Anthi scored substantially below peers. Speech production difficulties included substitution of /s/ with /θ/. Anthi was not able to produce the target phoneme in isolation or in DDK tasks.

Upon completion of the intervention programme and at follow up two months later Anthi's performance remained one and a half standard deviations below the mean performance of peers on 14 tasks.

6.5.2.1 Comparison of performance on baseline tasks pre and post intervention

In order to investigate whether there is significant change following intervention on general speech and language abilities, a comparison of performance accuracy on baseline assessment tasks was done. Pre and post intervention performance was compared for tasks that a) pre intervention met criterion of one and a half standard deviation below the mean performance of peers and did not meet this criterion upon completion of intervention, as shown in Table 6-9 and b) variables represented paired or matched data in a nominal scale, i.e. DVIQC, Bus Inf, Vocab, RWRepPolPCC, NWRepPhonPCC, NWRepPolPCC.

6.5.2.2 Comparison of performance on Language tasks

Anthi's accuracy scores, for language tasks can be seen in Table 6-10.

Table 6-10 Anthi's performance in language tasks at pre and post intervention time points

	DVIQ C				Bus Inf				Vocab			
	Two months pre	Immediately pre	Immediately Post	Two months post	Two months pre	Immediately pre	Immediately Post	Two months post	Two months pre	Immediately pre	Immediately Post	Two months post
Correct	20	22	25	27	13	14	30	26	20	20	28	29
Incorrect	11	9	6	4	45	44	28	32	30	30	22	21
Total	31	31	31	31	58	58	58	58	50	50	50	50

Diagnostic Verbal IQ test – Comprehension subtest (DVIQ C)

A Cochran's Q test indicated a statistically significant difference between scores for DVIQ C task at the four points of assessment (Cochran's Q = 14.50, df = 3, p= .002). Therefore, pairwise comparison of performance accuracy was performed using two-tailed McNemar tests. These indicated no significant difference between performance accuracy two months pre intervention and immediately pre-intervention (p=.500), immediately pre intervention and immediately post intervention (p=.250), immediately post intervention and at follow up two months post intervention (p=.500). The only statistically significant change was observed in DVIQC task between performance two months pre intervention and two months post intervention (p=.016*).

Renfrew Bus Story test – Information Score (Bus Inf)

A Cochran's Q test indicated a statistically significant difference between scores for Bus story task scored for information at the four points of assessment (Cochran's Q = 41.67, df = 3, p< .001). Therefore, pairwise comparison of performance accuracy was performed using two-tailed McNemar tests. These indicated no significant difference between performance accuracy two months pre intervention and immediately pre-intervention (p=1.00), immediately post intervention and at follow up two months post intervention (p=.125). A statistically significant change was observed in Bus Story task – information score between performance immediately pre intervention and immediately post intervention (p<.001) as well as between performance immediately pre intervention and two months post intervention (p<.001).

Renfrew Word Finding test – (Vocab)

A Cochran's Q test indicated a statistically significant difference between scores for Word finding task at the four points of assessment (Cochran's Q = 41.67, df = 3, p< .001). Therefore, pairwise comparison of performance accuracy was performed using two-tailed McNemar tests. These indicated no significant difference between performance accuracy two months pre intervention and immediately pre-intervention (p=1.00), immediately post intervention and at follow up two months post intervention (p=.125). A statistically significant change was observed in Word finding score between performance immediately pre intervention and immediately post intervention (p<.001) as well as between performance immediately pre intervention and two months post intervention (p<.001). Vocabulary score immediately post intervention was significantly better than pre intervention and this was maintained at follow up two months upon completion of the intervention program.

6.5.2.3 Comparison of performance on Output tasks

Anthi's accuracy scores, for output tasks can be seen in Table 6-11. Given that a significant change was observed in vocabulary score following intervention and that Naming accuracy was close to meeting criterion it was decided to include performance on Word Finding task, scored for Naming accuracy in the comparison of output tasks. To enable the analysis of percentages, the decimal digits are rounded to integer value. If the fractional portion of number is 0.5 or greater, the argument is rounded to the next higher integer. If the fractional portion of number is less than 0.5, the argument is rounded to the next lower integer.

Table 6-11 Anthi's performance in output tasks at pre and post intervention time points

	Naming PCC				RWRepPol PCC				NWRepPol PCC				NWRepPhon PCC			
	Two months pre	immediately pre	Immediately post	Two months Post	Two months post	Immediately pre	Immediately Post	Two months post	Two months pre	Immediately pre	Immediately Post	Two months post	Two months pre	Immediately pre	Immediately Post	Two months post
Correct	87	90	98	90	80	83	86	85	70	73	87	87	78	84	91	84
Incorrect	13	10	2	10	20	17	14	15	30	27	13	13	22	16	9	16
Total	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100

Naming

A Cochran's Q test indicated a statistically significant difference between scores for Naming task scored for PCC at the four points of assessment (Cochran's Q = 24.27, df= 3, p< .001). Therefore, pairwise comparison of performance accuracy was performed using two-tailed McNemar tests. These indicated no significant difference between Naming PCC performance accuracy two months pre intervention and immediately pre-intervention (p= .250). A statistically significant difference in Naming accuracy scored for PCC was found between performance immediately pre intervention and immediately post intervention (p=.008); between performance accuracy immediately post intervention and at follow up two months post intervention (p=.008); however, there was not a statistically significant change between performance accuracy immediately pre-intervention and two months post intervention (p=1.0). Compared to pre intervention performance, there was a statistically significant increase in Naming PCC accuracy post intervention that was not preserved at follow up two months post intervention.

Real Word Repetition Polysyllabic (RWRepPol)

A Cochran's Q test indicated a statistically significant difference between scores for RWRepPol task scored for PCC at the four points of assessment (Cochran's Q= 12.60, df= 3, p= .006). Therefore, pairwise comparison of performance accuracy was performed using two-tailed McNemar tests. These indicated no significant difference between performance accuracy two months pre intervention and immediately pre-intervention (p=.250); immediately pre intervention and immediately post intervention (p=.250); immediately post intervention and at follow up two months post intervention (p=1.00). A statistically significant change was only observed in RWRepPol task scored for PCC between performance two months pre intervention and immediately post intervention (p=.031*).

Nonword Repetition Polysyllabic (NWRepPol)

A Cochran's Q test indicated a statistically significant difference between scores for NWRepPol task scored for PCC at the four points of assessment (Cochran's Q = 26.08, df= 3, p< .001). Therefore, pairwise comparison of performance accuracy was performed using two-tailed McNemar tests. These indicated no significant difference between performance accuracy two months pre intervention and immediately pre-intervention (p=.250); immediately post intervention and at follow up two months post intervention (p=1.00). A statistically significant change was observed in NWRepPol task scored for PCC between performance immediately pre intervention and immediately post intervention (p<.001); immediately pre intervention and two months post intervention (p<.001). Performance accuracy on NWRepPolPCC immediately post intervention was significantly better than performance accuracy pre intervention; at follow up two months post intervention improvement was maintained.

Nonword Repetition Phonological (NWRepPhon)

A Cochran's Q test indicated a statistically significant difference between scores for NWRepPhon task scored for PCC at the four points of assessment (Cochran's Q = 24.27, df= 3, p< .001). Therefore, pairwise comparison of performance accuracy was performed using two-tailed McNemar tests. These indicated significant difference between NWRepPhon PCC performance accuracy two months pre intervention and immediately pre-intervention (p= .031*); between performance immediately pre intervention and immediately post intervention (p=.016*); between performance accuracy immediately post intervention and at follow up two months post intervention (p=.016). There was not a statistically significant difference in performance immediately pre intervention and two months post intervention (p=1.0). Compared to pre intervention performance, there was a statistically significant increase in NWRepPhon accuracy post intervention (that would not maintain significance under Bonferroni correction) that was not preserved at follow up two months post intervention.

6.6 Summary of findings

For both participants performance was stable in baseline assessment for a period of two months before the initiation of intervention. Both participants could not produce the target phoneme accurately in CV structure and consonant clusters. Baseline assessment prior to the beginning of intervention indicated that Harry had age appropriate language skills, performance on nonword auditory discrimination and picture choice tasks of speech input also did not meet the criterion; his difficulties were mostly apparent in output tasks of speech production. Anthi's performance fell –1.5 Standard Deviations below the mean of age appropriate in most tasks of speech, language and short term memory.

For the first participant Harry, upon completion of Phase 1 that targeted the production of /s/ in CV structure in phonological context performance on treated items improved and partial generalization to untreated /sk/ clusters was observed. Upon completion of Phase 2 that targeted the production of /s/ in syllable final word final position as a suffix of a) genitive case of feminine nouns in singular and b) accusative case of masculine nouns in plural, generalization was observed to untreated morphemes, i.e. to the accurate production of the accusative case of feminine nouns in plural that also requires the production of /s/ in word final position. Upon completion of Phase 3 that targeted the production of /s/ in CCV structure in phonological context i.e. /sk/ and /ks/ consonant clusters in the word stem, accurate performance was observed on treated items, untreated items and not targeted /st/ controls. Performance on not targeted /ps/ controls remained inaccurate. Upon completion of Phase 4 that targeted the production of /ks/ as a suffix of past tense accurate performance was observed on treated and untreated items, but performance on not targeted controls remained inaccurate. Two months upon completion of the intervention delivery Harry retained the ability to produce accurately /s/ in syllable initial, word initial and word within position, both for treated and untreated items. He was also capable of producing consonant clusters, those targeted in intervention i.e. /sk/ and /ks/ as well as untreated /st/. However, production of /s/ in word final position, when required for the manifestation of morphemes was inaccurate. He produced /ks/ as a morpheme of simple past accurately for some of the treated items and some of the untreated items.

For the second participant Anthi upon completion of Phase 1 that targeted the production of /s/ in CV structure in phonological context accurate production of treated items, untreated items and not targeted controls was observed. Upon completion of Phase 2 that targeted the production of /s/ in syllable final word final position as a suffix no accurate production of treated items, untreated items and not targeted controls was observed. Upon completion of intervention Phase 3 that targeted the production of /s/ in CCV structure in phonological context i.e. /sk/ and /ks/ consonant clusters in the word stem, accurate production was observed for therapy targeted treated and untreated items as well as for not targeted controls i.e. /st/, /z/. Upon completion of Phase 4 that targeted the production of /ks/ as a suffix of past tense there were no accurate productions. However, the child asked to have a second attempt and then she produced treated items, untreated items and most of not targeted control items accurately.

Performance accuracy on repeated probe assessments for the total of treated, untreated and control items when all or none of the treated items had been addressed in intervention i.e. immediately before and immediately after the provision of intervention, as well as at intervals without intervention, two months before the initiation of speech therapy and two months following its completion was compared using two tailed McNemar tests. For the first participant Harry a significant improvement in performance accuracy between probe assessments scores immediately pre-intervention and immediately post intervention was found for treated, untreated and control items. Intervention outcome was maintained after a period of two months without intervention for treated and untreated items. Post intervention there was no maintenance of intervention effect for Anthi. Anthi's performance on baseline speech processing input and output assessment post intervention was similar to pre-intervention performance. However, gains were made and preserved in language tasks.

Chapter 7. Discussion

The central hypothesis explored in this thesis is that the successful acquisition of the phonological and morphological characteristics of a spoken language depends on the accuracy and efficiency of speech processing skills.

Section 7.1 provides a discussion of the developmental course of different skills over time, methodological issues in assessment and cross linguistic differences between English and Greek.

Section 7.2 begins by laying out the theoretical dimensions of the current thesis such as the similarities and differences in the development of phonological and morphological characteristics, the factors affecting the development of lexical representations and the relationship between the development of speech processing abilities, language, phonological awareness and memory.

Section 7.3 is concerned with intervention for phonological and morphological targets.

Section 7.4 draws upon the entire thesis, tying up the various theoretical and clinical implications. Finally the conclusion gives a brief summary and critique of the findings.

7.1 The development of language and speech processing skills in Greek speaking children

Chapter 4 demonstrates how typically-developing children perform on different tasks assessing abilities of language, speech processing, phonological awareness and short term memory. This description is the first step in order to investigate the development of speech processing abilities in typically developing Greek speaking children. There appear to be developmental changes in performance for both groups of children, with this set of stimuli, on this range of tasks. These results are in line with previous findings in Greek speaking children (Ioannou, 2010) and in English speaking children (Nathan, 2001; Vance, 2001) showing a development of speech processing skills in the context of a child's general linguistic and cognitive development. Findings are discussed in sections 7.1.1.-7.1.4. Indications from the present study for the improvement of methodological issues to be addressed in future research in the field are considered in section 7.1.6.

7.1.1 Language tasks

In order to investigate morphological development globally, a variety of language assessment tasks have been used. In line with the hypothesis that there would be significant differences within each age group between testing points, most of the language tasks were sensitive in tracking change in language skills, although participants in group 2 seem to plateau between T2 and T3 in most tasks. The production of grammatical elements and vocabulary develop significantly between assessment points for both groups. It seems that major developmental changes occur between 3.6 and 4.5. After the age of 4.6 to 5.0 language development as measured on the tasks used has been attained to a large extent and further development occurs at a slower pace. Based on the assessment tasks used here, the earliest of these language skills to be attained appears to be sentence repetition, for which scores are close to ceiling by the age of 4.0 to 4.6. However, there were two areas where developmental change was not consistently found. Firstly, the spontaneous production of subordinate clauses did not significantly change between consecutive time points, although it did change significantly across longer time periods, suggesting that their development is relatively slow and gradual. According to Mastropavlou & Tsimpli (2011) young typically developing children (with a mean age of 3;2 years) produce in spontaneous utterances significantly smaller numbers of subordinate clauses than older children (with a mean age of 5;1). Although in the present study both groups exhibit comparable patterns with regard to the type of subordinate clauses produced, the frequency of embedded clause use is lower for younger children. Secondly, participants in group 2 performed at ceiling on sentence repetition, at T2 and T3 demonstrating they can repeat a number of sentence structures. Performance on sentence repetition is thought to be a measure of grammatical development and a reflection of sentence production in free speech. Research findings suggest that performance on sentence repetition relates to Mean Length of Utterance (Devescovi & Caselli, 2007; Stokes, Wong, Fletcher & Leonard, 2006) and is affected by morphosyntactic abilities (Seeff-Gabriel, Chiat, & Dodd, 2010). The significant improvement in sentence repetition indicates that there is an improvement in production capacity for complex syntactic structures. As children imitate a model in sentence repetition, the production of specific structures is mandatory, therefore the task has the potential to reveal a child's threshold of performance (Seeff-Gabriel et al., 2010). This might explain why over a period of six months there are no significant differences in spontaneous expression while significant differences are found in the repetition of sentences. The fact that participants in group 2 seem to plateau between T2 and T3 is probably an indication that by the end of pre-school period, by the age of five, typically developing children have mastered the fundamental structural aspects of language (Baird, 2008).

7.1.2 Auditory discrimination tasks

Auditory discrimination tasks have been used in order to investigate the development of speech input processing abilities. It was hypothesised that there would be significant differences in speech processing performance within each age group between testing points. Speech processing included both input (auditory) and output (production) tasks.

The auditory discrimination ABX tasks were sensitive to developmental changes between T2 and T3 for group 1, as well as between T1 and T3 for group 2. Performance of group 1 was below the level of chance at T1 and T2 and there were no significant differences found between scores at these time points, with the exception of Real Word Auditory Discrimination Morphological. It is possible that children responded by chance or that auditory discrimination skills were not sufficiently developed to allow performance above 23/30 (chance level). The small number of significant differences on performance of group 1 may be, in part, due to confounding variables, such as the conceptual demands, short term memory capacity and attention control requirements for the completion of the task. It was evident when collecting the data that attention control was quite inconsistent, particularly for the auditory discrimination tasks. This would possibly have more effect when more than one stimulus has to be retained, as in the case of the ABX tasks.

It may also indicate that stimuli characteristics, designed to be developmentally sensitive till the age of 6; 0, were beyond the potential of children at the age of 3;0-3;6 years. This view is supported by the fact that developmental change was observed in group 2 with this set of stimuli. It is possible that the use of different sets of stimuli for each group would have been more successful in identifying change in different age groups. Ioannou (2010) found a significant effect of time on nonword auditory discrimination in the performance of typically developing Greek speaking children from kindergarten through Grade A. However, in that study children had to decide whether stimuli AB were identical or different, so the cognitive demands of the task in terms of the amount of stimuli to be retained were different from those of the tests used in the current study. Vance (2001) found a significant effect of age on ABX nonword auditory discrimination task in English speaking children aged 3-7 years. Despite the fact that performance improved as children got older, according to Vance (2001) several children at the age of 5 and 6 years did not perform above chance.

Some dissociation was observed between phonological and morphological items for group 2 in the rate of development of auditory discrimination skills as measured by the ABX task. A significant difference in performance was noted between consecutive time points (T1 to T2, T2 to T3) for phonological items whereas for morphological items developmental change was only significant between T1 and T3. However, this was the only ABX task where significant development was observed for group 1 between T1 and T2. When performance on phonological and morphological items was compared in chapter 5, no effect of domain was found. It is possible that there is little or no effect of domain on the demands on the speech processing system. Rather, it is the phonological and morphological properties of the words that affect the sensitivity of tasks in tracking change at different ages. Morphological items were sensitive in tracking change between T1 and T2 in group 1 performance and phonological items were sensitive in tracking change between consecutive time points in group 2 performance. Task sensitivity may diverge or may become apparent at different points in development given that i) the number of morphemes in the language is restricted compared to the number of words, ii) a particular morpheme is repeatedly used in different words, iii) morphemes are used at boundaries, in word initial (prefix) or word final (suffix) position and iv) the phonotactic structure of morphemes is simpler (it may be V, CV, VC, or C) compared to the $C_{(0-3)}$-V-$C_{(0-1)}$ phonotactic structure of words (as presented in chapter 1).

During data collection, it was noted that children could cope with the task of auditory discrimination with picture choice more easily than ABX tasks. This may be because the task procedure (listening to a single word and pointing to the corresponding picture) is conceptually less demanding than the ABX design (listening to three stimuli and finding the two that are identical). This may also be because there were eight blocks of ABX and only two blocks of picture choice in the test battery, so that children got tired and lost interest for the task. According to Vance (2001) 3 year old children cooperated better in the task of auditory-visual lexical decision, while the test of ABX auditory discrimination was more demanding and some of them had difficulty in understanding the procedure. The performance of group 1 at T1 was the only instance of performance below the level of chance. The task proved to be developmentally sensitive, nevertheless, performance did not reach ceiling, not even for group 2 at T3. According to Vance (2001) children aged 5 years and above performed at ceiling on this task. Results of the current thesis may indicate that stimuli were successfully chosen to be taxing across the age range of 3;0 to 6;0 years. It is also possible that children did not have the necessary receptive vocabulary to cope with the semantic and phonological distracter of the target word.

A different set of stimuli was used in the Mispronunciation Detection task for polysyllabic items. Again performance of group 1 was below the level of chance at T1 and T2, although only one stimulus had to be attended to and thus the auditory memory demands of the task are slight. Hence, it could possibly be the case that the targeted speech processing demands of the task (as opposed to extraneous task demands) affect performance of group 1. Ioannou (2010) did not find an effect of age on mispronunciation detection performance of typically developing Greek speaking children from kindergarten through Grade A. However, stimuli in her study were 2-3 syllable long, whereas in the current study 4-5 syllable stimuli were used in the mispronunciation detection task. The incorrect productions which were incorporated into the stimuli as the 'mispronunciation' derived from the data of the pilot study, in order to reflect genuine mistakes made by typically developing children in that age range. It is possible that the test used in the current study is more ecologically valid – and this is why it picked up a genuine developmental change.

An essential point in the study of the development of the speech processing abilities, is to investigate how children store lexical knowledge and if there is developmental progression for the formation of precise representations. Performance in Picture Choice task, where young children performed above the level of chance from Group 1 T2 onwards, provides evidence that certain precise representations have been established by the age of 3; 6 to 4; 0. Nevertheless, even at the age of 5; 6 – 6; 0 the system has not been developed to the point that all representations are fully specified. Performance on Mispronunciation Detection is also indicative of developing accuracy of representations.

In summary, each of the input processing tasks was developmentally sensitive for the age range tested. Having taken account of task difficulty issues, these tasks appear to capture the development of input processing skills in typically developing children. As children in group 1 get older, there is a gradual increase of the means and there is a statistically significant difference in performance from the previous assessment point, although performance is still below the level of chance. From this it may be inferred that phonological representations progressively become more specified. However, stimulus characteristics and confounding variables may be affecting performance. Different tasks may be more representative of the maturity of the speech processing skills at different time points. In particular, auditory discrimination with picture choice may be a more suitable task for young participants.

7.1.3 Speech production tasks

Speech production tasks have been used in order to investigate the development of speech output processing abilities. Analysis of the data shows significant improvement in accuracy of speech production across time for both groups.

Both scoring methods i.e. scoring for whole word accuracy and for the percentage of consonants correct were sensitive in tracking change between consecutive time points in group 1. As regards group 2 scoring for whole word accuracy was more sensitive than scoring for PCC in identifying significant changes in performance. That was particularly evident in the naming task where whole word scoring yielded a significant improvement in performance between T1 and T2, T2 and T3, T1 and T3 whereas PCC scoring did not yield any significant change in performance. Nathan (2001) reports that in typically developing children there was a plateauing in speech development, reflected in ceiling effects.

A possible explanation for this might be that speech production accuracy is approaching ceiling for group 2. At this age children may only display minor difficulties such as the substitution of a single phoneme in a word, which are not sufficient in themselves to cause a significant difference in PCC scoring but which result in the whole word production being scored as incorrect. During the process of scoring the responses a number of such cases were observed. Inspection of the descriptive statistics indicates that for all speech production tasks, as children get older values of mean performance increase whereas values of standard deviation and range decrease. As data was collected from two groups of children direct comparison of performance could not be done. Nevertheless it is noticeable that there was a greater variability in the performance of group 1 at T1 that declined as children got older. In group 2 at T1 individual variation was less apparent and performance tended to be homogeneous over time. This may reflect stages of phonological development, in that by the age of 6 years most children have acquired an adult system. According to the stages of phonetic and phonological development (PAL, 1995) as presented in the Table 1:3 at the age of 5; 6-6; 0 Greek children have mastered all the consonants of the language as well as clusters of three consonants in initial position of words. Performance on the speech production tasks may reflect this mature system.

Performance in nonword repetition raises some concerns, since some nonwords may have lost their novelty as they were used in more than one task; this will affect interpretation of performance on nonword tasks. In nonword repetition children occasionally produced a real word. Although the number of lexicalizations was not counted, the effect of lexicality in speech processing was investigated in section 5.1.3 and will be discussed in section 7.2.1.3.

Nonwords presented for repetition had already been presented in the ABX discrimination task. Children were exposed to pairs of nonwords (nonword A, nonword B) presented in two blocks, each block presenting one stimulus of the pair (nonword X) to be identified as the same with either A or B. Children were asked to complete auditory discrimination tasks in session 1 and nonword repetition tasks in session 3 (as presented in Table 3-11). The aim was to complete the three evaluation sessions with each child in the course of one week, with a distance of 1 to 2 days between sessions. This has been achieved in most cases. In a few cases, the time interval was extended due to factors independent of the research process as for example when a child was absent. Sporadically, when children were asked to repeat a nonword (e.g. nonword A) they produced the alternative nonword of the pair (e.g. nonword B). This, in all probability, is an indication that the nonwords in the nonword repetition task were not completely novel to children. It is possible that some of the children had a temporary representation of a nonword that had already been presented three times in the auditory discrimination task. It is also possible that children accidentally arrived at the alternative nonword, because they could not remember or could not produce the target. Erroneous productions in target nonwords were observed in the range of tasks. In many cases these errors were novel nonwords, different from the ones used in the nonword pair, characterized by phoneme substitution, transposition or deletion of phonemes or syllables. Errors were also observed in the task of polysyllabic nonword repetition. In this task nonword stimuli had not been used in any of the input tasks, thus were completely novel. In mispronunciation detection, the input task for polysyllabic items, the stimuli used were mispronunciations of real words rather than nonwords. Matched stimuli were used across tasks to enable direct comparison of performance when processing requirements are not the same. Therefore, differences observed in performance between different output production tasks, may not be attributed to differences in stimuli difficulty. Differences observed in performance between different tasks allow us to form hypothesis about differences in speech processing demands. Priming effects like the example presented above were treated as an error. These errors were isolated incidents in the total number of the nonword repetitions of each child and were only observed in a small number of children.

With regard to speech output it seems that naming is more taxing than repetition tasks. Children also seem to perform better on tasks including Real Words rather than nonwords. Comparison of performance on different speech production paradigms was the focus of chapter 5. Factors affecting performance of the two groups, dissociations and associations in performance between tasks will be discussed in sections 7.2.1.1-7.2.1.5.

The speech production tasks were attractive to children. They enjoyed completing the real and nonword repetition tasks; they often showed impatience to proceed to the next one and in some cases disappointment when the administration of tests was completed. Stimuli presentation using software on a portable computer helped in maintaining their attention control. So far there is no data in the assessment of speech production in Greek preschool age children, with a presentation of stimuli via computer. However, it is a mode of presentation that retains children's attention in the process and for this reason it could be used both for research purposes and in clinical practice.

7.1.4 Phonological awareness

It is considered that the assessment of phonological awareness skills contributes to our understanding of the development of speech processing skills. Therefore, the development of blending and segmentation skills was expored. Analysis yielded a main effect of time on blending skills development for both groups. Phoneme blending develops gradually but is not fully attained by all children. Significant changes in segmentation performance between consecutive time points were found for group 1. Segmentation abilities seem to plateau upon acquisition of syllable segmentation for group 2. Syllable segmentation abilities emerged dramatically between 3; 6 – 4; 0 whereas phoneme segmentation followed a slow developmental process with great variation among children. A considerable amount of literature provides evidence that for children learning Greek, syllabic awareness is easier than phonemic awareness (Aidinis & Nunes, 2001; Giannetopoulou, 2003; Ioannou, 2010; Nikolopoulos, Goulandris, Hulme, & Snowling, 2006; Papadopoulos, Charalambous, Kanari, &

Loizou, 2004; Papadopoulos, Georgiou, & Kendeou, 2009). The development of phonological awareness and phonemic sensitivity begins well before the beginning of formal instruction (Aidinis & Nunes, 2001), when children have no letter-sound nor letter-name knowledge (Manolitsis & Tafa, 2011). However progression from syllabic awareness to phonemic awareness without literacy instruction seems quite challenging. Porpodas (2002) refers to the paradox that phonemic awareness is for Greek speaking children a particularly difficult skill in acquisition, despite the fact that children are able to understand the phonemic differences between words when listening to spoken language, even if the words are a pair with a minimal phonological difference, and use them correctly in language comprehension and production. The explanation given for this paradox is that in spoken language, phonemic units are co-articulated rather than separate. Porpodas (2002) expresses doubt that the nature of the syllable in the Greek language necessitates the awareness of within-syllable structure. Research in other languages with a similar syllabic structure to Greek indicates that preschool children learning Italian (Cossu, Shankweiler, Liberman, Katz, & Tola, 1988) and Portuguese (Cardoso-Martins, 1995) demonstrate higher levels of syllabic awareness than those reported for English-speaking children. Nikolopoulos, Goulandris, Hulme, and Snowling (2006) found that in Greek there is a rapid development of phonemic awareness following just a few months of reading instruction and exposure to the highly transparent orthography of the Greek language. The plateau of segmentation abilities following the acquisition of syllable segmentation in group 2, probably illustrates the difficulty of progressing to phoneme segmentation without literacy instruction.

7.1.5 Potential practice effects

In certain tasks it was observed that Group 2 at T1 (children aged 4;6 – 5;0) scored lower than Group 1 at T3 (children aged 4; 0 – 4; 6). This deviates from the pattern of steady chronological development. Better performance of Group 1 may be attributed to practice effect, since it was the third time participants had to cope with these tasks; it is possible that the procedure and the experimenter became familiar to children. For Group 2, the experience of being tested may have been unusual when they were assessed for the first time at T1. However, it is worth noting that participants in Group 1 were recruited in a day care setting at T1 and were still attending the setting at T3. Participants in Group 2 were recruited in a kindergarten school, which they had attended for a few months. Therefore it is likely that differences in the extent of schooling experience, socialization, interaction with peers may affect the development of speech and language skills and therefore affect performance in assessment tasks. Tomasello (2003) suggests that the development of language links to the need for cooperation in social interaction. Shared intentionality (joint attention, common ground) is fundamental for the development of communicative skills. In this line it is possible that the experience of social interaction within a context of preschool education, at least for one year, may have motivated the development of language skills of Group 1. It is not certain that all Group 2 participants had been exposed to such an experience before the first assessment.

7.1.6 Future directions – possible improvements to the test battery

Stimuli used in the tasks of phonological auditory discrimination derived from minimal pairs i) differentiated by the phonological properties of the constituent phonemes such as voicing and place of articulation and ii) with different phonotactic structure as a result of metathesis or cluster reduction. Stimuli of the latter case may not be developmentally appropriate for children aged 3;0-3;6, and this hypothesis could account for performance below chance as observed in this study. It is possible that children who performed below the level of chance had an objective difficulty with auditory discrimination between some of the pairs presented.

When assessing children and analyzing the data it was observed that some children made only one mistake in 30 items of the ABX auditory discrimination test, and for all the children that mistake was on the same specific item. Different sets of stimuli may be useful in ABX auditory discrimination tasks for different age groups. In developing the test for future clinical use, it will be important to carry out item analysis of stimuli in order to identify sensitive items to be used with different age groups. It may also elucidate the developmental progression of auditory discrimination skills.

An assessment of receptive vocabulary would have been informative for the interpretation of performance on auditory discrimination with picture choice task. It would also be interesting to further consider the type of mistakes i.e. semantic, phonological or unrelated to the target.

It may be useful to include a baseline ABX task including pairs of maximal opposition as a baseline to ensure that children have the required cognitive skills for the successful completion of the task. Performance on ABX task including minimal pairs could then be attributed to difficulties with speech processing rather than to difficulties with the conceptual understanding of the task.

It would be useful to extend the administration of the assessment battery to children younger than three years and older than six years, to monitor the development of speech processing skills in a larger age range. This would provide data on the early stages of speech and language development, thus would enrich our knowledge on the first speech processing abilities to emerge and the first language skills to be acquired. This would inform theory on the fundamental aspects of development. It would also inform clinical practice about the skills that may be treated in the first stages of intervention in order to motivate the development of the speech processing system. It would also provide data on the development of skills that have not been fully developed at the age of six, such as phonological awareness skills at the level of the phoneme, or the production of subordinate clauses in spontaneous speech. At the age of six years formal literacy instruction is introduced, so extending the assessment to older children would enable the investigation of the links between speech processing skills with literacy development.

It would be useful to administer the assessment battery to a clinical sample of children with speech difficulties, on the age range for which data from typically developing children are available. This would allow monitoring of the development of speech processing skills when the standard course of development is not followed and to compare processes of typical and atypical development. This will allow us to formulate hypotheses with regard to which weaknesses in constituents or processing levels of the speech processing system might underlie difficulties in speech and language development. This would inform clinical practice on areas of weakness that should be targeted in intervention.

It would be useful to include more phonological awareness tests, such as rhyme discrimination and rhyme production. This could be informative about the development of morphology, regarding the perception or production of particular endings. Rhyme judgment could be evaluated for morphemes that indicate:

i) a specific person in verbs, as for example [-ɛtɛ] second person plural in [ˈpɛzɛtɛ] (*you$_{(plural)}$ play*) vs. [ˈθɛlɛtɛ] (*you$_{(plural)}$ want*) [ˈpɛzis] vs. *(you$_{(singular)}$ play*),

ii) a particular case in nouns, as for example [-on] genitive plural in [moˈron] (*babys'* – genitive) vs [ˈfilon](*leaves')* vs [ˈfilɐ] (l*eaves*)

iii) a particular property as for example [ˈɐci](something small) in [sciˈlɐci] *(doggy)* vs. [ɣɐˈtɐci] *(kitty)* vs. [luˈluði] *(flower)*

This could provide information on whether the children are able to process the ending (morphology) or focus on the steam (semantics) of verbs, nouns and other inflected parts of spoken language.

7.2 Theoretical issues in speech and language development in typically developing Greek speaking children

Following the description of the development course of the speech processing skills discussed in section 7.1, investigation of the factors affecting the performance of children when processing phonological and morphological characteristics of speech and relationships between the development of different skills is discussed in the current section. In Chapter 5, data from typically developing Greek children on a variety of tasks were analysed in order to explore theoretical issues relating to the development of speech processing and language skills. Factors affecting the development of speech processing focusing on phonological and morphological characteristics are discussed in section 7.2.1. The relationships between different speech processing abilities, language skills, phonological awareness and memory are discussed in section 7.2.2.

7.2.1 Factors affecting development of speech processing

Identification of factors affecting the development of speech processing abilities is important for a better understanding of how the speech processing system develops. In order to investigate factors that may be affecting development of speech processing skills a series of analyses was conducted contrasting results from different tests within and between levels. Testing *within* levels establishes if children are able to complete a task with a certain set of stimuli while they perform differently when different stimuli are used. Examples are items of phonological vs. items of morphological interest; or items of 2 or 3 syllables vs. items of 4 or 5 syllable, which can throw light respectively on how linguistic domain and how motor programming may influence the accuracy of children's speech processing performance.

Testing *between* levels is a way to identify differences in the children's component speech processing skills within and across time. For example comparison of performance on tasks involving real words vs. nonwords can be used to investigate the role of prior linguistic knowledge in children's speech processing at a particular age. Dissociations and associations in performance between tasks presented in sections 7.2.1.1 - 7.2.1.5 illuminate whether differing processing components or routes are involved in the developing speech processing system.

7.2.1.1 The linguistic domain

This study set out with the aim of investigating the speech processing of phonological and morphological characteristics of words both in typically developing children and children with speech disorders. It has been proposed that the levels of phonology and morphology are interrelated (Crystal, 1987). According to Mastropavlou (2010) phonology may have a facilitatory role in the acquisition of morphology in Greek speaking children. In reviewing the literature no data was found on the association between phonology and morphology in terms of speech processing requirements. It was hypothesized that speech processing requirements are similar for any spoken-word language material and that there would not be an effect of the linguistic domain i.e. phonology or morphology in input and output processing of real words. In order to explore the development of morphological elements as part of the developing speech processing system, it was investigated whether comparable speech processing skills are involved in input processing of both phonological and morphological characteristics of spoken language.

The results of this study show that there is not a significant difference in input processing between phonological and morphological items as assessed in ABX real word auditory discrimination. Although children scored slightly higher on Real Word Auditory discrimination with morphological than with phonological stimuli, this was not a significant effect and the pattern of development was similar for both domains. These data must be interpreted with some caution because of the below chance performance of Group 1. However, it seems highly likely that the low attainment of Group 1 demonstrates objective auditory discrimination difficulties, as the development of the speech processing system is not yet complete.

Turning to output processing in repetition tasks, there was a discrepancy between the two scoring methods used. Whole word scoring did not indicate an effect of linguistic domain in

Real Word Repetition for group 1. A just significant overall linguistic domain effect in favour of phonological items was found for group 2 when whole word scoring was used, however comparison of means did not indicate a statistically significant difference between phonological and morphological items at any of the individual assessment points. On the other hand, when percentage consonants correct (PCC) was used as the measure, a linguistic domain effect was found in favour of morphological items for group 1, as was a significant interaction between time and domain for both groups. In order to track developmental change, phonological stimuli were designed to be quite challenging in terms of phonotactic structure, including consonant clusters and close syllables. Blocks of phonological and morphological stimuli were not balanced in terms of word length or phonotactic structure of the stimuli i.e. there were not equal numbers of 2, 3, or 4, syllable stimuli in phonological and morphological blocks, nor equal numbers of stimuli including consonant clusters. Selecting stimuli that were not equally balanced in phonological and morphological blocks could be a bias, picked up by the sensitive PCC scoring that yielded a domain effect at the younger end of the age range. The strict measurement of whole word scoring did not replicate these findings.

Evidence for the existence of a main effect of linguistic domain in real word repetition is thus inconsistent in the present study. It may be the case that these variations are due to stimuli characteristics. Newbold, Stackhouse, and Wells (2013) point out that different scoring procedures may be differently affected by stimuli characteristics. In the present study, phonological items were devised so as to reflect differences in consonant clusters and phonotactic structure of minimal pairs. Morphological items were devised so as to include fine tuned differences mainly in word endings. Both tasks proved to be developmentally sensitive in tracking change in speech production skills over time, however, different scoring methods potentially uncovered change in different elements. It is possible that when the more sensitive PCC scoring was used, it could detect the gradual change in producing subtle differences between the morphological pairs, thus it revealed an interaction between time and domain for both groups. It is also possible that the production of consonant clusters and closed syllables included in phonological stimuli was more taxing on output production. Therefore, analysis yielded a linguistic domain effect in favour of morphological items for group 1 when PCC scoring was used.

On the other hand when the stricter measure of whole word accuracy was used, there was no linguistic domain effect for Group 1, presumably because the speech production skills of

Group 1 are still immature, which will be reflected both on phonological and morphological items. Whole word scoring yielded a just significant linguistic domain effect in favour of phonology for Group 2. It is possible that when the extent of misarticulated phonemes is not taken into account, the production of complex morphemes within a word is challenging. Nevertheless, a statistically significant difference was not detected at any time point between the two domains.

It should be kept in mind that morphological stimuli were chosen from among the stimuli included in the language comprehension (DVIQC) and language production (DVIQP) tasks. Stimuli were chosen on the basis of their morphological properties, such as morphemes indicating tense, number, gender. These stimuli were then used to assess speech processing skills. Stimuli included in phonological and morphological blocks were not balanced in terms of word length, for example equal numbers of 2, 3, 4 syllable stimuli were not included in phonological and morphological blocks. In addition stimuli were not balanced in terms of phonotactic complexity. Phonological stimuli were chosen so as to include consonant clusters and close syllables. Equal numbers of stimuli including consonant clusters could have been used in phonological and morphological blocks. It is possible that selection of the specific stimuli may have to some extend been a bias in performance. Finally, it would have been useful to include stimuli in the test blocks according to the frequency of use of specific morphemes or phonotactic structures in the language, but this was not possible as there were no such data available at the moment.

Nevertheless, there is no evidence in the results of the present study to suggest that morphological items pose specific challenges for children in terms of speech processing, either in input or in output processing. In line with the initial hypothesis, this suggests that speech processing requirements are similar for any spoken-word language material, irrespective of the linguistic domain.

7.2.1.2 Word length

There is a well established effect of word length in output speech processing performance of English speaking children (James et al., 2008). It was investigated whether there is such an impact of word length on the development of speech processing skills for Greek speaking children, given the high frequency of polysyllabic words in Greek language. There was a significant effect of word length, repetition accuracy significantly decreasing for longer stimuli. A word length effect was evident for Group 1 both for real words and nonwords across all time points; however, difference in performance between 2-3 syllable items and 4-5 syllable items became less significant over time. Group 2 performed better on 2-3 syllable items in comparison to 4-5 syllable items but this difference in performance was significant only at T1 and T2. Thus it seems that as children get older repetition accuracy for longer items increases. The output processing abilities of the older Group 2 seem to have developed to such an extent that the length of items did not have an effect on performance at T3. Results provide evidence in support of the hypothesis for a word length effect in performance.

The finding that repetition of 2-3 syllable items is more accurate than repetition of 4-5 syllable items could be interpreted in terms of short-term memory requirements, i.e. the need to hold longer strings of phonemes for repetition (Gathercole, 2006). Previous studies, such as Smith (2008), found a similar effect of nonword length on repetition accuracy in preschool age Greek children with SLI and younger language matched controls, which was not evident in older typically developing controls who had been matched on age to the children with SLI. Smith (2008) attributed this difference in performance between groups to short term memory requirements rather than output difficulties, because the nonwords used were of simple phonotactic structure. In the current study polysyllabic stimuli were not of simple phonotactic structure. Word length effect is interpreted in terms of speech processing; this pattern implies that the older participants' speech production skills such as motor programming and motor execution are better developed than those of the younger participants, allowing for the more accurate production of polysyllabic items.

These results seem to be consistent with findings for English speaking children (Vance, Stackhouse, & Wells, 2005; James, van Doorn, McLeod, & Esterman 2008) reporting that stimulus length has an effect on speech production accuracy. This effect decreases as age increases and there is an interaction between age and number of syllables (James, van Doorn, McLeod, & Esterman, 2008).

Production accuracy for polysyllabic words has clinical significance. Assessment of polysyllabic words seems to be vital in identifying speech production errors in older children (Vance et al., 2005) and in recognizing speech difficulties (James, van Doorn, & McLeod, 2008). Since there is an effect of age on production accuracy of longer words , the fact that a child produces polysyllabic words less accurately than words of shorter length is not in itself an indication of difficulty. It is important to have data on how accurate the production of polysyllabic words would be in typical development, to evaluate whether performance of a child is an indication of difficulty, i.e. if performance reveals residual difficulties or if it is as would normally be expected because of the greater demands posed by longer words.

7.2.1.3 Lexicality

It was explored whether stored representations may support lower level processing for phonological and morphological elements of speech, and whether the magnitude of this potential effect changes as a result of development. A lexicality effect in favour of real words was evident for Group 1 in auditory discrimination of items of phonological interest and for both groups of children on all speech production tasks.

It seems that the speech processing requirements of discriminating the phonemes of a real word in comparison to a nonword are only facilitated with top-down support in the case of phonological minimal pairs in Group 1. As for morphological items, it is possible that when children are exposed to morphemes in single word utterances, without context, then there is no association of input stimuli to stored lexical knowledge.

One possible explanation for the absence of the lexicality effect for morphological items could be that the morphological nonwords were not pure nonwords, because they had to contain real morphemes of the Greek language. The component differentiating one nonword from the other in auditory discrimination is a difference between components that represent real morphemes of language; these morphemes are attached to nonword stem, thus are found in nonword context.

It is also possible that since morphological pairs were not always minimal pairs in terms of their phonological properties, auditory discrimination between them was less demanding so that children did not have to rely on representations to complete the task. The number of phonologically – maximal, morphologically minimal pairs was limited, and therefore was probably insufficient to generate a domain effect.

The fact that there was no lexicality effect in auditory discrimination performance for group 2 either for morphological or for phonological items provides evidence in support of this view. Provided that phonological recognition skills are sufficiently developed to support the process of auditory discrimination, children do not have to access stored representations to support or confirm a decision. Phonological recognition is the fundamental skill for the task of auditory discrimination and so the sub-lexical route could be used. It is also possible that since input processing skills are sufficiently developed children can discriminate between novel stimuli equally as well as known words.

Turning to output processing, both in real word and nonword repetition children were exposed to an adult model of the target. Real words represent stimuli for which existing lexical knowledge may be available so children may possibly access these stored representations, including stored motor programs, when asked to repeat real words. In the present study, real word repetition performance was significantly more accurate than performance on nonwords i.e. novel stimuli the children had never said before, for which new motor programs had to be generated. It thus seems that top-down processing had an advantageous effect on speech production and that children in both groups made use of existing lexical representations to support real word repetition. The findings for Group 1 of the current study differ from those of Vance et al. (2005) who did not find a significant difference between real word and nonword repetition accuracy at the age of 3 years. Results of the present study match those reported by Vance et al. (2005) that at age 4 years real word repetition was significantly more accurate than nonword repetition and this pattern sustained till the age of 6 years. It is possible that 3 year old English speaking children 'process both words and nonwords presented for repetition in a similar way, favouring a bottom-up approach to both in which no use is made of lexical representations' (Vance et al., 2005, p. 43), whereas Greek speaking children of the same age favour a top-down approach to real word repetition, similar to that observed in older children both in English and in Greek. Cross-linguistic differences such as the polysyllabic nature of Greek could be a possible cause for this difference in the developmental pattern. It is likely that in order to cope with the demands of long words, the children refer to the stored representations, to draw upon the existing knowledge for the completion of the task.

The significant difference in performance between real words and nonwords for both groups rules out the possibility that lower level motor execution skills have a specific effect on nonword repetition performance. Rather, inferior performance in nonword repetition has been attributed to difficulty in creating new motor programs (Stackhouse & Wells, 1997) as well as to limited input processing skills (Dollaghan, Biber, & Campbell, 1995). For the younger children (Group 1), auditory skills are still developing, and so this may contribute, along with motor programming limitations, to their poor nonword repetition performance;

whereas for the older children (Group 2) the relatively poor nonword repetition performance can be attributed solely to motor programming. As there is no support from top down processing skills, possibly nonword repetition is more taxing than real word repetition, as information has to be maintained for a sufficient time to allow phonological recognition of stimulus heard and motor planning for repetition. The weaker performance in nonword repetition may also indicate a difficulty in motor programming skills, as a prerequisite for the creation of new motor programs (Stackhouse & Wells, 1997).

7.2.1.4 Level of processing

Tasks requiring access to representations are considered to be more demanding than tasks where stored information can be used but it is not essential for the completion of the task (Sutherland & Gillon, 2007). The role of stored representations for the successful completion of input speech processing tasks was explored. Comparison of performance between Real Word ABX auditory discrimination and the picture choice task yielded a main effect of level of processing for both groups. Children performed better on the ABX task, where it was not necessary to access stored lexical representations. However, as reported above, a lexicality effect had been found in auditory discrimination for stimuli of phonological interest in Group 1 but not in Group 2 performance. It is possible that children in Group 1 use a lexical route in order to complete the task of auditory discrimination. Despite the fact that stored lexical representations may assist auditory discrimination, there is a significant difference in performance when children have to rely on stored lexical representations to complete a task. A significant difference was found between performance when access to stored representations is required and when stored representations may optionally be used to support processing. Participants in Group 2 may have developed their phonological recognition skills to such an extent that the possibility of accessing stored representations is not necessary in supporting auditory discrimination performance, therefore there is not a significant difference between real and nonword auditory discrimination. Group 2 participants perform significantly better when they have to discriminate between real words in comparison to when they have to reflect on the accuracy of the real word they have heard. It is difficult to untangle the role of stored lexical representations in auditory discrimination of real words. Superior performance in tasks that do not depend on stored representations for completion have also been reported for English speaking children (Sutherland & Gillon, 2007).

7.2.1.5 Modality of processing

It is explored whether processing of phonological and morphological elements of the speech poses different demands in different modality i.e. in input and output modality. In order to investigate the effect of perceptual and motor dimensions on speech processing, performance was compared between input and output tasks tapping into the same level of processing. Comparison of performance of real word processing for items of phonological and morphological interest between input and output tasks did not yield an effect of processing modality on performance accuracy. With respect to known words, it is possible that once typically developing children attain the essential perceptual ability for the discrimination between words and the creation of accurate phonological representations they simultaneously develop the corresponding motor skills for the creation of distinctive motor programs.

Comparison of performance of nonword processing yielded an effect of processing modality in favour of auditory discrimination that was only evident in processing items of morphological interest and not phonological interest. The superior performance of auditory discrimination compared to repetition in processing nonwords of morphological interest may possibly indicate that, when children are exposed to novel linguistic material including morphemes, they have adequate perceptual skills to discriminate these but they do not simultaneously create the corresponding motor programs. Nonwords including real word properties, i.e. nonwords including morphemes used in real words, may be processed differently or performance may be affected by other factors beyond the control of the experimenter such as word likeness. Given that stimuli of morphological interest were in certain cases more than 3 syllables long it is also possible that stimuli length was a bias taxing on motor programming skills. Children were able to repeat real words of morphological interest using top down support whereas they did not have the necessary motor programming skills for the accurate repetition of nonwords.

The fact that there was not a significant difference in performance between the input and output tasks, is in line with the suggestion of Rees (2001) that in the speech processing system input and output modalities are closely integrated. The fact that the modality effect was not significant for phonological nor for morphological words indicates that both follow a similar pattern of processing.

7.2.1.6 Summary

To summarize results on factors affecting speech processing development in Greek children, data provide evidence in support of the hypothesis that phonological and morphological characteristics of spoken language pose similar demands on the speech processing system. There was no evidence in the results of the present study to suggest that morphological items cause specific challenges for children in terms of speech processing, either in input or in output processing. It was rather found that phonological and morphological stimuli pose similar demands both in input and output modalities. The possibility of accessing stored representations facilitates processing, especially in output tasks. Production accuracy decreases as length of stimuli increases.

7.2.2 The relationships between different speech and language skills

In order to better understand the development of speech processing skills, in particular skills for processing of morphological elements, possible associations between speech processing, language and short term memory were investigated. Pearson correlation analyses were used to examine specific associations between processing of phonological and morphological items and more general associations with language and cognitive skills. It was hypothesized that processing of phonological items would correlate with processing of morphological items. It was also hypothesized that measurements of input processing would correlate with measurements of output processing and language development. Vocabulary was expected to relate to speech processing skills, accuracy of stored phonological representations and language. Performance on short term memory tasks was expected to relate to language comprehension but not to auditory discrimination skills.

7.2.2.1 The relationship between processing of phonological items and processing of morphological items

In a study of past tense production in Greek, Mastropavlou (2010) found that in cases where past tense declaration requires a stress shift the performance of typically developing children is better than in cases where no stress shift is required. Based on this data it was suggested that phonology may have a facilitatory role in the acquisition of morphology for Greek speaking children. The findings of Mastropavlou (2010) allow the hypothesis that good processing of phonological elements of the language relates to good morphological development. In order to explore the development of morphological elements as part of the developing speech processing system, potential relationships between processing of phonological and morphological elements in input and output tasks were investigated. It was hypothesized that positive correlations would be found between processing of phonological and morphological stimuli, between input tasks as assessed with real word auditory discrimination and output tasks as assessed with real word repetition.

Auditory discrimination scores for phonological and morphological items were significantly associated within time (i.e. synchronically) at T2 and T3 for group 1 as well as at T1 and T3 for group 2. Results on the input side suggest that a relationship exists to some extent between performance on phonological and morphological tasks. The development of adequate phonological recognition skills, required for the auditory discrimination of phonological elements relates to the development of phonological recognition skills for the auditory discrimination of morphological elements.

Performance on real word repetition of phonological and morphological items was significantly associated within time (synchronically) at T1, T2 and T3 for both groups and diachronically across all time points for group 1. This suggests that production of morphemes relates to the ability to produce phonological elements of the language. The degree to which children have developed the necessary skills to generate motor programs required for the task of real word repetition for phonological items, relates to the degree of these skills development for morphological items.

On the production side, correlations were found at every time point for both groups between performance on tasks of phonological and morphological interest. Results on the input side are less conclusive about a relationship between performance on phonological and morphological tasks. This may be attributable to the fact that on input tasks performance can be affected by the intrusion of random choice, as well as memory and attention requirements that are sometimes higher than for output tasks.

In summary there is a relationship between processing of phonological and morphological items, not only in output but also in input processing, although this relationship is less evident in input because performance is likely to be more affected by extraneous requirements of the tasks.

7.2.2.2 The relationship between input processing and output processing in typically developing children

Nathan (2001) found highly significant relationships between output and input processing in typically developing children: ‘these results show that co-occurrence is relatively common in children with speech difficulties and also indicates that there are relationships between these components of processing in normal development’ (p.357). Research also suggests that children with speech sound disorders experience difficulties with auditory discrimination (Edwards, 2002; Rvachew & Grawburg, 2006). In order to explore the development of different components of the speech processing system, the relationship between input and output modalities was evaluated. It was hypothesized that performance in input and output processing tasks would associate when stimuli characteristics are the same. However, the current study did not replicate this finding for Greek speaking children. Correlations were not found for any age group between input and output processing performance i.e. ABX auditory discrimination and repetition tasks, whether stimuli were real words or nonwords.

This suggests that for typically developing Greek children aged 3;0-4;5 and 4;6-6;0 accurate repetition is not related to auditory discrimination skills. This may be attributed to a number of cross-linguistic differences such as the limited number of phonological minimal pairs and the high frequency of polysyllabic words in Greek. Given the nature of the Greek language and the more salient auditory differences between Greek words it is possible that children do not have to develop auditory discrimination skills to the same extent as children learning English. It is possible that for the perception of polysyllabic words temporal-order skills are more important than discrimination of single phonemes. Conversely, in order to produce polysyllabic words, Greek-speaking children might need to develop their motor programming skills to a greater extent and /or earlier than children who speak English. Sequencing skills may thus be important both for linguistic decoding and encoding. To the best of the writer’s knowledge there is no such study in the Greek language. Assessment with a psychoacoustic mainly non–verbal test battery found auditory processing disorder to be co-existing with developmental dyslexia Greek children (Iliadou, Bamiou, Kaprinis, Kandylis, & Kaprinis, 2009). The ability to perceive and recall the correct sequence for parts of words could be the subject for future research. It could also be informative to investigate the relationship between auditory discrimination and speech production in younger participants than here, where the minimum age was 3. It might also be revealing to use stimuli of 1 syllable rather than of 2 or more syllables as were used here, since the former may place more demands on auditory discrimination rather than short term memory skills.

7.2.2.3 The relationship between speech processing and language development

Auditory discrimination skills have been found to correlate with later language development (Tsao, Liu, & Kuhl, 2004) and vocabulary (Edwards, 2002). Research data suggest that poor speech perception may explain poor word production (Ziegler, et al., 2011). Previous studies (Nathan, 2001; Vance, 2001) investigating the relationship between speech processing and language in English speaking children report on relationships between input processing and language. According to Vance (2001) there is a significant predictive relationship between auditory discrimination scores and the development of receptive language skills. According to Nathan (2001) longitudinally there are highly significant correlations between earlier language measures and later speech processing measures. It was investigated if there is a relationship between language development and speech input processing, in particular processing of phonological and morphological elements of speech . Analysis of the current data did not yield significant relationships between auditory discrimination skills and language comprehension or vocabulary production, within or across time. This disparity in results may be attributed to cross linguistic differences between English and Greek, as discussed in 7.2.2.2. It is also possible that such a relationship may exist for children younger than three years, in the early stages of speech and language development. Tsao, Liu & Kuhl (2004) found that language development at the age of two years related to auditory discrimination skills at the age of just six months.

7.2.2.4 The relationships between vocabulary development, accuracy of stored phonological representations and phonological awareness

It is explored whether the formation of accurate representations within the speech processing system relates to vocabulary development and the development of phonological awareness skills. Given the frequent use of polysyllabic words in the Greek language the possible relationship is investigated both for 2-3 syllable words and for polysyllabic words. Significant correlations were found between vocabulary production and the accuracy of stored phonological representations both for 2-3 syllable words and 4-5 syllable words for Group 1. These results are in line with theories suggesting that growth of the size and diversity of vocabulary leads to reorganisation and specification of phonological representations (Metsala & Walley, 1998) to allow for sufficient differentiation between lexical items (Walley, 1993). Research into developmental word finding difficulties indicates that imprecise phonological representations may be at the root of difficulties with vocabulary comprehension (Crosbie, Dodd, & Howard, 2002) and vocabulary production (Constable, Stackhouse, & Wells, 1997).

The relationship between vocabulary production and naming accuracy was significant for Group 1 and highly significant for Group 2. This is compatible with the suggestion by Nathan (2001) that there may be a top-down effect of vocabulary growth on speech production skills. The expansion of vocabulary leads to the development of output processing skills, which in turn enables the accurate production of an increasing number of words.

Statistically significant relationships were found between segmentation skills and vocabulary production within and across time, particularly for Group 2. This is in line with the suggestion that as a child's vocabulary grows, phonological representations become increasingly segmented as a prerequisite for adequate segregation between lexical items (Nittrouer & Crowther, 1998; Walley, 1993). 'Because phonological awareness tasks measure a child's knowledge of the sounds within words, it is a reasonable hypothesis that this awareness is highly dependent on the status of a child's lexical representations' (Carroll, Snowling, Hulme, & Stevenson, 2003, p.914).

7.2.2.5 The relationships between vocabulary development, language development and phonological awareness in a morphologically rich language

For the better understanding of how the comprehension and production of morphology develops in Greek children, the development of language competence (as assessed in language comprehension and production tasks) is investigated in relation to the development of parameters such as vocabulary and phonological awareness. Correlation analyses yielded relationships between vocabulary production with language comprehension and production for both groups. Highly significant correlations were found within and across time between vocabulary production and mean length of utterance for Group 1. These results are in line with the findings of Devescovi et al. (2005) that vocabulary size significantly contributes to mean length of utterance development. The contribution of vocabulary to mean length of utterance development is larger than the contribution of age in English speaking and Italian speaking children. Findings of the present study may be indicative of general linguistic competence expressed in vocabulary production, comprehension of grammar and syntax and production of syntactic structures.

With regard to the relationship between phonological awareness and language, it was observed in Group 2 that there were significant correlations between performance in segmentation with the subsequent performance in the language comprehension (DVIQC) and language production (DVIQP) tasks. Such a pattern of relationship between segmentation and language development did not appear for Group 1. It is possible that as children get older, segmentation skills become important for comprehending and producing more complex linguistic structures. These findings corroborate the view that in morphologically rich languages segmentation skills emerge in early stages of language development as a means of managing inflections (Ziegler & Goswami, 2005).

7.2.2.6 The relationships between short term memory, language and speech processing

STM is thought to influence vocabulary development (Gathercole & Baddeley, 1989), language comprehension (Florit, Roch, Altoe, & Levorato, 2009), language production (Adams & Gathercole, 1995, 2000) and syntax (Blake, Mysczyszyn & Jokel, 2004). For the better understanding of the development of language skills and speech processing skills development it was investigated whether these skills relate to the development of STM skills.

A significant relationship was found between language comprehension and short term memory particularly for group 1, but there was no significant relationship between short term memory and vocabulary production or between short term memory and language production. These results are consistent with earlier findings (Chrysochoou & Bablekou, 2011; Chrysochoou, Bablekou, Masoura, & Tsigilis, 2013) that in Greek short term memory supports vocabulary development for a shorter period than in English. It is possible that in a highly inflectional language with free word order such as Greek, there are different demands for short term memory support in language development than in English. Context may be essential for children in order to understand how different inflected word forms relate to the same word semantics.

It is noteworthy that the task that most frequently correlated significantly with language comprehension and production measurements, particularly for group 2, was sentence repetition. Evidently this task taps into language abilities (Seeff-Gabriel, et al., 2010, Devescovi & Caselli, 2007); it may also be more representative of real world linguistic experience than a short term memory task requiring children to recall word lists.

A relationship was found for both groups between scores on sentence repetition and vocabulary production. It has been suggested that sentence repetition is a measure of Phonological Short Term Memory (Willis & Gathercole, 2001) however this is strongly debated as there is evidence that sentence repetition is a pure measure of language development (Seeff-Gabriel et al., 2010). No relationship was found between vocabulary and short term memory as assessed with tasks requiring the repetition of word lists. Chrysochoou, Bablekou, Masoura, and Tsigilis (2013) provide evidence that in Greek speaking children the relationship between short term memory and vocabulary declines earlier than in English. In their study receptive vocabulary did not associate to any of four short term memory measures.

It seems that in the early stages of development there is a relationship between short term memory capacity and language comprehension. Short term memory has been suggested as a factor affecting the development of language comprehension (Florit, Roch, Altoe, & Levorato, 2009), language production (Adams & Gathercole, 1995) and syntax (Blake, Myszczyszyn & Jokel, 2004). Data from the current study provides evidence in support of the role of memory in language development as there was a relationship between language comprehension and short term memory task performance (measured with the number of words recalled from a word list and the number of word lists recalled in the correct order) at T1 and T2 for Group 1. These results are in line with findings of Chrysochoou & Bablekou (2011) that in preschool years short term memory contributes to oral comprehension overall. This effect, stronger in the preschool years, decreases with age.

Auditory discrimination tasks require children to maintain in memory the stimuli presented in order to decide on similarity or difference with the target. However, there was no correlation between ABX auditory discrimination performance with memory as measured with the number of word lists recalled in the correct order, suggesting that ABX performance reflects competency in phonological recognition rather than short term memory capacity. This demonstrates that ABX auditory discrimination task is a valid auditory measure.

7.2.2.7 The relationship of processing of polysyllabic items to STM, integrity of phonological representations, segmentation abilities and vocabulary

Since polysyllabic words are frequently used in Greek, it was explored whether the same relationships between the development of polysyllabic words with STM skills and speech processing skills that have been found for children who speak English also apply to children who speak Greek. Increased stimulus length is supposed to pose greater demands on short term memory capacity (Gathercole, 2006) and so inferior performance on repetition of lengthy items by young typically developing children has been attributed to short term memory deficits (Smith, 2008). However, in the current study repetition of polysyllabic items did not correlate to short term memory measurements for either group. There were highly significant relationships between scores on repetition of polysyllabic items with the other repetition tasks i.e. real and nonword repetition of phonological and morphological stimuli, indicating that different output production tasks depend on the same output production skills, such as motor programming and motor execution. It seems that the adequacy of speech production skills is related to the performance accuracy in all production tasks involving repetition. It also seems that precise phonological representations relate to good repetition performance for polysyllabic items. Word length is believed to increase short term memory requirements since the amount of information to be retained is greater (Gathercole et al. 1991), however results of the present study do not provide evidence in support of this hypothesis.

Significant relationships were also observed between mispronunciation detection for polysyllabic items and repetition performance for the same items. This indicates that motor programming skills depend on to some extent to the accuracy of stored phonological representations.

There was no within time (synchronic) correlation between segmentation skills and polysyllabic word production. Diachronic relationships were found for Group 2 between accuracy performance on repetition of polysyllabic items at T1 and T2 with segmentation skills at T3. It is possible that the phonemic processing required in polysyllabic stimuli repetition relates to the development of subsequent segmentation skills (Snowling, 1991).

7.2.3 Summary of normal speech processing development in Greek

With respect to the development of speech processing skills in Greek language and the development of morphology in relation to the development of speech processing skills, the analysis of the longitudinal data, presented in chapters four and five and discussed in the preceding sections can be summarized in the following points:

1. The assessment tasks used are suitable to detect developmental change as children get older. Participants in Group 2 reach ceiling and demonstrate a plateau in performance in certain tasks.
2. Significant change is observed in the development of auditory discrimination skills, although performance of Group 1 is below the level of chance. Morphological stimuli are more sensitive in identifying developmental change in Group 1 and phonological stimuli are more sensitive in detecting development in Group 2.
3. There is a significant change in speech production abilities both spontaneously and in repetition. Participants in Group 2 reach ceiling in certain tasks. The score for the overall accuracy of the word is more sensitive than the percentage of consonants correct in detecting changes in typically developing older children.
4. A developmental progression is observed in the specificity of stored lexical representations which is manifested by changes in performance on real word

auditory discrimination with picture choice, mispronunciation detection and naming tasks.

5. A developmental succession is observed in phonological awareness skills when assessed using segmentation and blending tasks. There seems to be a plateau in progression from syllabic to phonemic awareness.
6. There was no evidence to suggest that morphological items pose specific challenges for children in terms of speech processing. Correlation analysis yielded significant relationships in performance between processing of phonological and morphological items.
7. Word length is a factor affecting performance. As length increases accuracy decreases. This pattern fades away with age: as children get older repetition accuracy for longer items increases.
8. Lexicality is a factor affecting performance, particularly in output tasks. Children perform more accurately when there is the possibility of accessing stored lexical representations.
9. Vocabulary production was found to be significantly related to the accuracy of stored phonological representations, language comprehension and language production.
10. Language comprehension was found to be significantly related to short term memory skills, for Group 1 at T1 and T2. This relationship decreased with age.

7.2.4 The significance of investigating normal speech processing development in Greek

Since languages vary in their phonological and morphological structures, they may also vary in the demands they pose on the developing child. The study of speech processing skills and language development in Greek, revealed the following cross-linguistic differences in comparison to English speaking children as reported in the research literature:

1. For Greek children good repetition did not relate to good auditory discrimination skills.
2. In the age range studied with this test battery there was no relationship between input processing and language development.
3. There was no relationship between short term memory and vocabulary production.

For the purposes of the present study a test battery of speech-processing skills for Greek was developed for children aged 3;6 – 6;00. It proved be acceptable to the children participating in this study, indeed they were on the whole keen to complete it. This opens up the possibility of using the battery in other research and clinical settings since:

1. It provides data, not available until now for the performance of typically developing children learning Greek, on tests that relate to a wide range of speech and language processing skills.
2. The battery can be used to identify whether an individual child is following the anticipated typical course of development.
3. For a child who does not follow the typical developmental stages, assessment with this test battery may be informative as to the skills in which this child deviates from normal.
4. The comparison of the performance of a child with that expected for his age is the first step in order to evaluate performance on different tasks and draw conclusions about the possible areas of weakness. For example, for a young child performing below the level of chance on auditory discrimination tasks, comparison with data of typically developing children may indicate whether performance is age appropriate or an area of weakness. For a child repeating nonwords less accurately than real words, comparison with data of typically developing children may indicate whether performance may be attributed to the effect of lexicality or may be an indication of motor programming difficulties.
5. The published tools that are currently available for Greek clinicians focus on the production of speech. The findings of the current study highlight the importance of developing assessment tools for input skills, as well as for the accuracy of lexical representations.
6. Experience suggests that in everyday clinical practice in Greece, emphasis is placed on semantics and naming accuracy rather than phonological representations. Currently in Greece children are constantly asked to say the word accurately, while mispronunciation detection may be equally important. This study provides the resources and may encourage clinicians to assess the accuracy of phonological representations.

7.3 Intervention targeting phonological and morphological skills

Chapter 6 presented single case studies of intervention targeting phonological and morphological units. Intervention case studies were carried out with two children who do not have the necessary speech processing skills for the accurate production of a phoneme that is used in morphological context. It was explored how underlying speech difficulties may be manifested in language production, i.e. how may the production of morphophonemes be affected. It was also explored whether intervention targeting specific speech processing skills may lead to the accurate production of morphemes. The production of /s/, a phoneme used in multiple phonological and morphological contexts, was targeted in alternating phases of phonological and morphological focus. Changes in the production of treated targets and generalization to untreated targets were measured at each phases of intervention, in order to assess phonological and morphological change. The effect of intervention was evaluated when the domains of phonology and morphology were directly treated. It was also evaluated following treatment phases targeting the other domain, for example change in the morphological field occurring when the set intervention goals were in phonology. Given the findings of the normative study it was expected that phonological and morphological stimuli would pose similar demands for the children in intervention. Therefore, similar intervention procedures would be effective for both and generalization on either of the domains could occur as a result of intervention targeting the other. Given the findings of the normative study, that the development of phonology and morphology are based on similar speech processing skills, it wass expected that whether the focus of intervention is on phonological or morphological elements, intervention would have broad-spectrum beneficial effect on language and speech processing skills.

7.3.1 Response to intervention

7.3.1.1 Harry

The overall performance of Harry during and upon completion of intervention allows some conclusions to be drawn.

1. With regard to the generalization of /s/ in other phonological contexts, when therapy follows a phonological direction, it appears that once Harry was able to produce /s/, there was partial generalization to other phonotactic structures. Upon completion of

Phase 1 when /s/ was targeted in CV structures, Harry was able to produce the phoneme in untreated items with the same phonotactic structure as well as in a few items with /sk/ cluster. Upon completion of Phase 3 when /s/ was targeted in /sk/ and /ks/ clusters Harry was able to produce accurately control items with /st/ but not /ps/. However, it is worth noting that generalization to the proper production of /z/, the voiced equivalent of the targeted phoneme, was never observed.

2. Concerning the generalization of /s/ in other morphemes, when therapy follows a morphological direction, it appears that Harry was able to generalize to the appropriate production of other morphemes that require /s/ in word final position. Upon completion of Phase 2 untreated targets and not targeted controls were accurately produced.
3. Regarding generalization to appropriate production of /s/ in morphemes, once phonological targets are set in intervention it seems that no such generalization occurred. Upon completion of Phase 1 Harry substituted /s/ with /ɬ/ in word final position when it was required for the accurate production of morphemes. Upon completion of Phase 3 Harry was able to produce /ks/ in syllable initial word within position, when included in the word stem, both for treated and untreated items. Nevertheless, he substituted /ks/ with /kɬ/ in all productions of verbs in simple past tense, which entail the cluster in syllable initial, word within position.
4. With regard to gains in phonological domain when intervention targets the production of morphemes, it seems that there was some generalization to phonological targets. Upon completion of Phase 2 that targeted the production of /s/ in word final position for morphological purposes, Harry was able to produce /sk/, which had not been targeted yet, despite the fact that there were no accurate productions of /s/+vowel, which had been targeted in the preceding phase. Upon completion of Phase 4, which targeted the production /ks/ as a morpheme of simple past tense, there was an improvement observed in the production of untreated items with /sk/ and /ks/ clusters, in comparison to performance on the same items upon completion of Phase 3, which had targeted those clusters.
5. With regard to general speech processing abilities, in the course of two months prior to intervention delivery, statistically significant change had not been observed in tasks that met the criterion of one and a half standard deviation below the mean, which suggested that he was not improving spontaneously in these skills as a result of

> maturation. However, comparison between performance immediately pre and immediately post intervention with two tailed McNemar tests indicated statistically significant change post intervention in RWAudDMor, Naming PCC, RWRepMor, RWRepPol PCC, NWRepMor PCC, NWRepPol PCC. Performance at follow up two months post intervention was significantly better compared to pre – intervention. Although in certain tasks accuracy rate at follow up decreased in comparison to performance immediately post intervention, it still remained higher than pre-intervention.

Two months following the end of the intervention program, maintenance of correct production of phonological targets seemed to be better compared with morphological ones. Although there may be non-morphological use of the final /s/ in the Greek language in some adverbs which are not inflected, the final /s/ is mainly used in inflected categories such as verbs, articles, adjectives, nous, pronouns and participles. In the case of Harry, the production of /s/ in the word final position was not preserved at all, even though in some cases there had been an improvement immediately following intervention. A possible explanation could be that phonemes found at the word end in comparison to phonemes in the word stem are more vulnerable, due to the co-articulation with phonemes which follow. Another explanation could be that morphophonemes are not predetermined in one word. The phoneme /s/ in word final position is not required in each case of a noun. So the frequency of its use is lower than in instances where the phoneme is in the word stem and so is obligatory whenever the word is used. This view is supported by the fact that accurate production of /ks/ in word-within position is higher when included in the word stem than when it is required to form a simple past tense morpheme.

Speech therapy intervention had positive effects for Harry. It seems that he not only developed the lower level execution skills for the production of /s/, but also that phoneme had become specified at the level of lexical representations, enabling him to create more accurate motor programs. This applies not only to the words that have been targeted in intervention (treated items) but also to words with identical properties (untreated control items) and words with similar characteristics (not targeted controls). This improvement is observed in probe assessment as well as in performance on output tasks in the baseline battery. Comparison of Harry's performance pre and post intervention reveals a statistically significant increase in PCC accuracy rate in output production tasks.

7.3.1.2 Anthi

The overall performance of Anthi during and upon completion of intervention allows some conclusions to be drawn:

1. With regard to generalization of /s/ in other phonological contexts, when therapy follows a phonological direction, it seems that Anthi was able to use the principles for the correct production of /s/ and /s/ clusters in single word naming task. Upon completion of Phase 3 that targeted the production of /s/ clusters Anthi was able to produce the phoneme in untreated items, as well as in control items with /z/, and clusters /st/, /ps/ that had not been targeted in intervention.
2. Concerning the generalization of /s/ to other morphemes when speech therapy follows a morphological direction it seems that any intervention outcome extended to untreated items. However it is not clear that the correct production of morphemes in general is a result of treatment, as the correct production of treated morphemes does not coincide with the phases in which they were targeted.
3. Regarding generalization to appropriate production of /s/ in morphemes, once phonological targets are set in intervention it seems that some generalization occurred. Upon completion of Phase 3 that targeted the production of /ks/ in the word stem Anthi was able to produce accurately the same cluster in 2/6 items as a suffix for verbs in simple past tense, which had not yet been targeted in intervention.
4. With regard to gains in the phonological domain when intervention targets the production of morphemes, wide variation is observed in Anthi's performance. Upon completion of Phase 2 there were no accurate productions of treated or untreated items. Upon completion of Phase 4 the first attempt at the probe assessment resulted in no accurate productions, and the second attempt was a complete success.
5. With regard to general language and speech processing capabilities, it seems that there was a positive effect of the intervention program. Comparison of performance immediately pre and immediately post intervention with two tailed McNemar tests indicated statistically significant change post intervention in Vocabulary and Information provided in Bus Story test that was retained at follow up two months post intervention. Statistically significant change was also observed post intervention in Naming PCC, NWRepPol and NWRepPhon. However, at follow up performance was similar to pre-intervention performance, with the exception of NWRepPol.

It seems that speech therapy intervention affected mainly Anthi's lower level execution skills. She was quite focused on following traditional articulation therapy instructions on placement for the production of the phoneme. Most times her performance was characterized by accuracy in the production of all or none of the probe assessment items. The most remarkable example of this is the difference between the first and second attempt in probe assessment upon completion of intervention phase 4 (presented in 6.5.1.2). When focused on the task, Anthi could control the movement of articulators at a lower level of motor execution; when she was less focused, there was no volitional control of oral movements and existing motor programs were used resulting in inaccurate productions. It seems that intervention activities targeting lexical representations did not result in Anthi updating stored motor programmes.

7.3.2 Evaluation of the intervention outcome for both case studies

Response to intervention was different for the two participants, highlighting the need for individual assessment and intervention for each child. However, the pattern of change as a result of intervention allows some conclusions to be drawn about the effect of intervention in the two domains of interest and the interaction between them. The pattern of generalization observed post intervention may be informative on how the lexicon might be organised. Intervention case studies are one way to investigate connections between the morphological and the phonological components of the speech and language processing systems. The experimental intervention case studies were designed in order to explore the extent to which speech therapy intervention aimed at developing phonological or morphological skills impacts on the development of speech, language or both. The effect of intervention is discussed within domain (sections 7.3.2.1-7.3.2.2), across domain (sections 7.3.2.3-7.3.2.4), as well as in relation to general speech and language abilities (section 7.3.2.5). A brief summary and review of the findings is given in section 7.3.3.

7.3.2.1 Generalization of a phonological target to other phonological targets

The main research question informing the intervention case studies is whether the effect of treatment is limited to words that have been targeted i.e. if intervention has been effective for the specific features of speech that were addressed, or if it leads to a broader change in the speech processing ability of the children.

The first issue to be considered here is whether the phonologically targeted therapy for the production of the phoneme /s/ in a certain position will facilitate the production of this phoneme in other positions and structures. With respect to generalization of a phonological target to other phonological contexts, both participants showed more accurate production of untreated items and control items upon completion of intervention phases than they had shown prior to intervention. Once Harry was able to produce /s/ in a certain treated structure or word position, there was partial generalization to untreated items with the same phonotactic structure as well as to other phonotactic structures, for example consonant clusters, in the probe naming task, although generalization did not extend to the accurate production of /z/, the voiced counterpart of /s/. Anthi's response to phonological therapy led to the correct production of /s/ and /s/ clusters in untreated items, as well as in control items with /z/, and /s/ clusters that had not been targeted in intervention, in the probe single word naming task.

Thus both participants showed some generalization to other lexical items, other phonotactic structures or to a closely related phoneme. Across item generalization has been commonly reported as an intervention outcome in the literature of speech sound disorders (Pascoe et al., 2005; Seeff-Gabriel et al., 2012; Waters et al., 1998). The current study is the first study reporting controlled intervention for speech difficulties with Greek speaking children which led to a significant improvement in performance on intervention targets and generalized improvement in speech and language skills.

7.3.2.2 Generalization of a morphological target to other morphological targets

The next matter to be considered is whether therapy aiming at the production of a morpheme that requires the phoneme /s/ will facilitate the production of other morphemes that require the accurate production of the same phoneme. This question has not apparently been addressed in earlier research, for example Tyler, Lewis, Haskill & Tolbert (2002) do not report on a morphological intervention outcome with other untreated morphemes.

With regard to generalization of /s/ in other morphemes, when therapy follows a morphological direction, the two participants show different responses to intervention. It appears that Harry was able to generalize to the appropriate production of untreated morphological targets and not targeted controls that require /s/ in word final position. In the case of Anthi it seems that any intervention outcome extended to untreated items, however it is not clear that the correct production of morphemes in general is a result of intervention, as the correct production of treated morphemes did not coincide with the phases in which they were targeted.

7.3.2.3 The effect of phonologically oriented intervention on production of grammatical morphemes

The next question to be considered is whether therapy aiming at the production of the phoneme /s/ in phonological contexts will facilitate the production of morphemes that require the accurate production of that phoneme. If there is a common output lexicon for both phonological and morphological forms, then it would be expected that intervention addressing the accurate production of phonological features, would result in improved speech production of morphological features. With regard to the effect of phonologically targeted intervention on the accuracy of morpheme production different patterns of across-domain generalization were observed in the two children. In the case of Harry no such generalization occurred. This was particularly evident upon completion of Phase 3. Although Harry was able to produce target /ks/ accurately as [ks] in syllable initial word within position (SIWW), when included in the word stem both for treated and untreated items, he substituted it with /kɬ/ in all productions of verbs in simple past tense, which entail the same cluster in the same word position (SIWW). On the contrary some generalization occurred in the case of Anthi. Upon completion of Phase 3 Anthi was able to produce /ks/ cluster accurately as a suffix for verbs in the simple past tense, which had not yet been targeted in intervention.

Harry’s response to intervention is in line with the finding of Tyler et al. (2002) that greater gains in morphosyntactic performance come from morphosyntactic intervention. Anthi’s response to intervention supports the suggestion that an intervention strategy treating phonology to a criterion might be the preferred strategy for children whose morphological difficulties are attributed to phonological limitations (Tyler, Lewis, Haskill, & Tolbert, 2003). In order to achieve integration of morphological suffixes in spontaneous speech, Vance (1997) targeted the phonological details of those suffixes. As a result of intervention there was some awareness and use of these endings, but this was not systematic. This indicates that in some cases the development of phonological competence for the production of morphemes may be sufficient to trigger the production of accurate morphemes even on a non systematic basis.

7.3.2.4 The effect of morphologically oriented intervention on the production of phonemes

The next issue to be considered is whether therapy aiming at the production of the phoneme /s/ in specific morphemes, will facilitate the accurate production of the phoneme in other phonological positions and structures. Although Seeff-Gabriel et al. (2012) in their single-case design study did not investigate the effects of morphological intervention on speech, according to Tyler et al. (2003) in group studies cross-domain effects from morphosyntax to phonology are greater than the effects found from phonology to morphosyntax.

If grammatical representations form an integral part of lexical representations, then it would be expected that intervention addressing the accurate production of /s/ in morphemes, would result in improved speech production of the phoneme /s/ in a range of phonological contexts. Within the speech processing model proposed by Stackhouse and Wells (1997), updating stored motor programs of words with the intention that morphemes can be accurately generated could be expected to stimulate motor programming skills, leading to some revision or updating of the child's current motor programs for phonological targets. In the case of Harry increased production accuracy was observed for phonological targets following intervention Phase 2, which targeted morphemes. Wide variation is observed in Anthi's performance. Upon completion of Phase 2 there were no accurate productions of treated or untreated items. Upon completion of Phase 4 the first attempt resulted in errors on all items and the second attempt resulted in all items being correctly produced. Thus with regard to gains in the phonological domain when intervention targets the production of morphemes; it seems that there was some generalization to phonological targets for both participants.

7.3.2.5 Change in general speech and language abilities as a result of intervention

With regard to general speech and language abilities it seems that there were beneficial effects of the intervention program for both participants; however, gains were different for each of them.

Harry's performance at follow up two months post-intervention was significantly better compared to pre-intervention. Performance accuracy on phonological targets was better preserved compared to morphological ones and significant gains were preserved in a broader range of speech/phonological abilities. Although in certain tasks accuracy rate at follow up decreased in comparison to performance immediately post intervention, it still remained higher than pre-intervention. Comparison of Harry's performance pre and post intervention reveals more than 10% increase in PCC accuracy rate in output production tasks, which was statistically significant. This gain in PCC accuracy is similar to findings of intervention studies with English speaking children, such as those of Gillon (2000), McNeill et al. (2009), and Tyler et al. (2003) who also report PCC improvement slightly above 10% (13.2%, 13.1%, 12.4% respectively). It seems that Harry developed lower level execution skills that enabled him to produce phoneme /s/ (targeted in intervention) not only in treated items but in a wider range of positions and phonotactic structures. He developed the necessary motor programming skills that led to significant improvement in nonword repetition accuracy for polysyllabic items post intervention and at follow up. He specified the phoneme /s/ at the level of lexical representations as indicated by significant improvement in mispronunciation detection performance two months post intervention compared to immediately pre intervention performance. He also created more accurate motor programs as indicated by significant improvement in naming accuracy post intervention and at follow up compared to pre intervention performance.

With regard to language assessment pre intervention Harry's performance met criterion of – 1.5 S.D. below the mean performance of typically developing children in a number of language tasks i.e. in sentence repetition, the amount of information provided in narratives as assessed with Bus Story test, experimental assessment of language comprehension (DVIQCExp) and production (DVIQPExp). Upon completion of intervention and two months post intervention delivery Harry's performance for a second time met criterion of -1.5 S.D. below the expected mean score for his age on sentence repetition and amount of information provided in narratives. Following completion of intervention, Harry's performance on experimental language comprehension (DVIQCExp) and production (DVIQPExp) tasks improved to such an extent that no longer met the criterion of -1.5 S.D. below the mean, in line with his performance on the core language comprehension (DVIQC) and production (DVIQP) tasks from the outset of the study. Harry's language skills had developed to the expected for his age level in the majority of tests. Generalized change as a result of intervention was observed in speech processing and tasks tapping on the accuracy of stored lexical representations such as naming and mispronunciation detection, rather than in language skills, to which major difficulty had not been observed.

Anthi's performance at follow up showed no maintenance of intervention outcome on the production of phonemes targeted in intervention. With regard to general language and speech processing capabilities, it seems that there was a statistically significant change post intervention in Vocabulary and Information provided by the Bus Story test that was retained at follow up two months post intervention. This indicates a general rather than specific outcome of intervention. Anthi showed improved performance on language measures without improving on speech measures. This suggests that spoken language improvements are not dependent on phonological improvements. However, the fact that no significant change was observed in Anthi's language skills during the period of two months from the commencement of the study (first assessment) until the beginning of intervention (second assessment) indicates that the observed changes came as a result of intervention. It is likely that as Anthi was involved in speech therapy activities, including auditory discrimination, repetition and naming activities, intervention motivated an interest for spoken language. It is possible that intervention drew her attention to the fact that words have certain distinctive features and that there are specific articulatory requirements. Despite the fact that changes in speech were not maintained at follow up, during the intervention program it was attempted to improve the skills of phonological recognition, to update phonological representations and to develop more accurate motor programs. Working on the speech processing skills may have triggered metalinguistic awareness and language development resulting in significant improvement in skills that had not been directly targeted during intervention phases.

7.3.3 Comments on intervention case studies

At the beginning of the study, both children had the same exposure to formal schooling as age matched peers to whom they are compared. Harry attended a nursery setting and had not yet received kindergarten education, whereas Anthi was attending kindergarten school. However, comparison of performance on baseline assessment between participants in the intervention study and peers of the same age participating in the normative study should be made with caution because of possible practice effects, given that data from peers were collected at T3.

Baseline assessment prior to the beginning of intervention indicated that Anthi's performance fell –1.5 Standard Deviations below the mean of age appropriate in most tasks of speech, language and short term memory. Harry on the other hand had age appropriate language skills, performance on nonword auditory discrimination and picture choice tasks of speech input also did not meet the criterion; his difficulties were mostly evident in output tasks of speech production. Anthi's performance on probe assessment fluctuated between assessment phases whereas Harry's performance revealed a gradual development of abilities and generalization to untreated items and to not targeted controls. Post intervention there was no maintenance of intervention effect for Anthi on treated items while Harry's ability to produce accurately a considerable number of treated items was maintained. In addition Anthi's performance on baseline speech processing input and output assessment post intervention was similar to pre-intervention performance, although gains were made and preserved in language tasks. Harry's performance on Mispronunciation detection was above the level of chance, his performance on output tasks improved notably and anecdotal evidence suggests that spontaneous speech improved as well.

This presentation of the capacities of the two children in the baseline assessment prior to the commencement and subsequent to the end of intervention, performance in repeated probe assessments upon each phase during the course of intervention and the divergent responses of the two participants to this, demonstrate the uniqueness of each case and the importance of studying intervention on an individual level.

Anthi is a relatively older child, more than five years of age. Pascoe et al (2006) suggest that speech difficulties after the age of five are persistent. It is possible that Anthi's relatively low response to intervention is a result of not being referred at a younger age. Furthermore, Anthi is a child with co-occurring difficulties in speech and language. According to Haskill &

Tyler (2007) co-morbidity of difficulties in both areas accumulates the severity of these difficulties making them resistant to change. It is possible that in Anthi the impact of intervention is general, manifested with improvement in the area of vocabulary and information provided in narratives. Harry showed some improvement on the production of /s/ clusters upon completion of Phase 4 that had a morphological orientation. This improvement may indicate that the longer the intervention time for a child, the greater the skills and generalization observed. On the other hand it may be compatible with the statement of Tyler, et al. (2002) that addressing the morphosyntactic level leads to improvements at the phonological level, equivalent to the improvement observed when the goal is purely phonological. For some morphemes, it is necessary to use an entire phrase to elicit their production. Thus an activity targeting the production of a particular morpheme may be more demanding and children may be exposed to more demanding stimuli compared with a picture or a single word stimulus as is often used for the speech production of phonological targets.

Harry needed intervention that aimed at /s/ production at the end of words for morphological purposes, although he was able to use this phoneme in word initial and word within positions. In addition intervention targeting the production of /ks/ as a morpheme for simple past tense was required, despite the fact that Harry was already capable of generating the phoneme in the stream of words. It seems possible that acquisition of accurate production of morphemes, as in the case of /ks/ as a morpheme for simple past tense, for children who attempt to mark the morpheme, even if the segment used is not the correct one, as in the case of Harry at intervention Phase 4, require the same speech processing principles as are followed for the achievement of phonological objectives.

As in the case described by Seeff-Gabriel, et al. (2012) acquisition of /s/ did not automatically lead Harry to the production of /z/. Neither did the development of /s/ in word initial position automatically lead to the phoneme's production in word final position. This may indicate that Harry did not store /s/, the phoneme targeted in intervention, as a single member of the sound system that can be used in different phonotactic positions. Sometimes similar targets need to be treated separately.

Bryan & Howard (1992) showed that acquisition of a phoneme does not necessarily lead to update of already existing motor programmes. By analogy it cannot be taken for granted that acquisition of a phoneme will inevitably lead to update of existing lexical representations, whether the elements of stored representations that have to be updated are related to semantic, phonological or grammatical linguistic knowledge.

To summarize findings of the intervention case studies, the outcome for the two participants shows that their individual responses to the intervention strategies were different; suggesting that results for other children undergoing similar interventions may vary considerably. Forrest, Dinnsen, and Elbert (1997) suggest that differences observed in substitution patterns among different children with speech sound disorders, may account for differences in intervention outcome. This highlights the need to assess and treat each child separately, tailoring intervention to the individual profile of strengths and weaknesses. Moreover, it is possible that children with similar speech processing profiles will demonstrate different response to intervention tasks (Waters, 2001). Individual differences, learning style and motivation may account for differentiated response to intervention. Even though each child is unique, single case study intervention research can lead to recommendations for different ways of intervention delivery, provide evidence on intervention strategies that have been successful and inform theoretical understanding of speech processing development. Once results from a larger number of cases have accumulated, it should be possible to suggest which approach might be more efficient when a particular profile of difficulties is encountered. Cross linguistic research may contribute in formulating hypotheses about how the speech processing system is organized, at what levels difficulties may arise and how the treatment affects the underlying cognitive components of the speech processing system to induce change.

In the present study, cross item generalization was observed both within and across domain. The literature suggests that once a phoneme is targeted in a certain position there may be generalization to the production of that phoneme to other positions (Elbert & McReynolds, 1975; Pascoe, Stackhouse, & Wells, 2006; Seeff-Gabriel, Chiat, & Pring, 2012). This study shows that there may be generalization from the production of a phoneme required for morphemes to the production of phonological characteristics of words. This allows the hypothesis that morphological characteristics are an integral part of lexical representations. Phonological representations and motor programs may need to be specified as to the different morphemes that can be attached in semantic representations (a word stem).

Let us use the example of the word cat. Originally there is the semantic representation of a small, furry pet with whiskers. For the Greek language this word has a stem [ˈɣɐt-] and various endings [-ɐ], [-ɐs], [-ɛs], with different morphological functions that can be used to generate different forms of the word i.e. [ˈɣɐtɐ] *(cat)* nominative singular,[ˈɣɐtɐs](*cat's)* genitive singular referring to a part or a feature of the cat, such as the cat's whiskers, [ˈɣɐtɛs] *(cats)* nominative/accusative plural. If each morpheme had a discrete representation, then across item generalization would not be expected. For example if different representations existed for the word forms [ˈɣɐtɐs] *(cat's*) and [ˈɣɐtɛs] *(cats)* then across item generalization would not be possible. However, as shown in the case of Harry, updating motor programs to be used for certain morphemes impacts on the accuracy of production of other morphemes. Targeting the production of genitive case in singular e.g. [ˈɣɐtɐs] (*cat's)*, results in accurate production of not targeted controls of accusative case in plural e.g. [ˈɣɐtɛs] *(cats)*. This suggests that the stored knowledge of a word consists of the form of the word (phonological representation) and the necessary gestures for the accurate production of the word (motor program), both for the word stem and the possible word suffixes. Furthermore, updating motor programs to be used for certain morphemes impacts on the accuracy of stored motor programs for phonological targets, as indicated by improved naming performance of phonological stimuli upon morphological phases of intervention presented in section 7.3.2.4. The development of speech processing skills required for the identification and production of morphemes may be beneficial for the development of the speech processing system.

Previous research suggests that intervention on certain /s/ clusters does not necessarily generalize to other/s/ clusters (Pascoe et al., 2006). The present study provides evidence in support of the idea that this sound set of /s/ clusters in Greek language may need to be a separate subject of treatment. Although Harry generalized to the accurate production of /ks/, before it was targeted in intervention and /st/ that had never been targeted in intervention, he did not generalize to the accurate production of /ps/, even after the last phase of intervention.

In a comprehensive intervention for speech sound disorders certain cases may require targeting of the production of morphemes as well as phonemes. This is comparable to the need, for some children, to target each cluster separately. Morphemes may need to be targeted in intervention, even in children with speech sound disorders without accompanying language difficulties, in the case that speech errors are involved in morpheme production.

Targeting accuracy in morpheme production may lead to increased performance accuracy for phonological targets.

Despite the fact that intervention delivery to the children took place in a clinical context, the intervention was designed in an experimental way. This entailed some divergence from routine clinical practice. In everyday clinical practice once something is set as a target in the intervention, the clinician may provide feedback on errors at any suitable occasion, whenever these are noticed. The fact that at certain stages of this experimental intervention program, some domains should remain untreated changes the nature of the intervention. There may therefore be a disparity between what would have been the result of a clinical rather than experimental approach. In addition, factors beyond the control of the investigator, such as the parents' attitude towards the difficulty and their feedback to the child when speech was not fully intelligible may have had an impact on intervention outcome.

7.4 Concluding remarks

The present study of Greek-speaking children has contributed to our knowledge about the development of speech processing, language and short term memory skills in the context of a highly inflectional language. Evidence was based on data from typically developing children aged 3;0-3;5 and 4;6-5;0 at the beginning of the study, assessed longitudinally on a range of tasks and from intervention single case studies of children with speech and/ or language difficulties.

This study set out to investigate the development of phonological and morphological characteristics of the Greek language. One of the more noteworthy findings to emerge is that differences in processing of phonological and morphological items are not significant. Relationships between the processing of phonological and morphological items within or across time were partially demonstrated. Different levels of linguistic analysis such as the levels of phonology and morphology are used to describe and analyse linguistic material and instances of language disability (Crystal & Varley, 2013). However, data from the current thesis do not provide significant evidence for differences in processing between phonological and morphological units. Language is an integral system, and speech processing skills, along with cognitive skills such as memory and attention, are necessary for the comprehension and production of verbal communication (as presented in chapter 2). The extent to which and the time during which the speech processing system affects the different components of the language can vary for each component.

This investigation at certain points confirms research findings for the English language, such as the effect of word length and lexicality in processing. However, differences are also observed, such as in the role of speech input skills in production and the role of short-term memory in vocabulary development. These differences may be associated with cross-linguistic factors such as the greater prevalence of polysyllabic words, the simpler phonotactic structure, and the more complex conjugation system of the Greek language.

The results of the present investigation of speech processing skills of typically developing Greek children have some implications for the identification of speech and language difficulties in Greek. A major problem at the moment is the classification of speech and language difficulties according to research-based criteria, due to the need for standardized Greek-language tests of auditory discrimination, word and nonword repetition, diadochokinetic rate and the limited number of standardized language tests currently available. This thesis has gone some way towards meeting this need, by creating some new tests and assembling a test battery.

In this study the data from the vocabulary production task was used for investigation of naming accuracy. Further research needs to be done in order to have a battery that uses matched items to assess naming and repetition of words and nonwords. This will allow direct comparison of different production tests and identification of levels at which difficulties may be identified.

Apart from the test of auditory discrimination with picture choice, it may be useful to evaluate the accuracy of phonological representations for 2-3 syllable words, with mispronunciation detection, to explore the components of inaccurate phonological representations.

Performance on auditory discrimination tasks was not found to relate to output production and language skills. However, discriminating between minimal pairs that differentiate by one phoneme may not be representative of auditory discrimination demands for the acquisition of Greek language. A next step in research would be to evaluate auditory discrimination with regard to sequencing of syllables and phonemes within a word.

Tasks of rhyme judgment and rhyme production using morphemes as the rhyming component may be useful in further investigating the ability to process morphological components of the words.

Assessment of vocabulary comprehension along with language comprehension and vocabulary production should be included in future assessments. This will enable a better evaluation of the development of semantic representations.

Task materials and procedures used in the present study need to be evaluated further in order to exclude tests where ceiling and floor effects were observed. The next step shall be the development of a test battery with tasks of graded difficulty to be used for different age groups.

The results of this study also have some clinical implications. Given the present evidence, morphology merits attention in intervention for speech sound disorders, even in the absence of a concomitant language difficulty. Each child, either presenting with severe and persisting difficulties, or presenting with concomitant speech and language difficulties is unique and may therefore need to be assessed and treated individually according to the profile of strengths and weaknesses.

The contribution of the present study firstly on the theoretical knowledge for the development of language and speech processing skills in preschool age, secondly for clinical practice in children with speech difficulties and/or language can be summarized in the following points:

1. An assessment battery was designed, which can be used as a starting point for the evaluation of speech processing skills and language skills of Greek speaking children in future studies in the field.
2. The assessment battery may be used to diagnose children with speech difficulties in Greece.
3. The study introduced the evaluation of speech processing for the morphological components of language.
4. Some cross linguistic differences between Greek and English speaking children were identified. These may inform theories of speech and language development.
5. Experimental intervention case studies have demonstrated that selection of specific targets and intervention procedures was effective in bringing change to intervention targets and general speech and language skills.

Much still needs to be known about how children develop speech, language and cognitive skills at different stages of typical and atypical development. More research is required to understand the reciprocal relationship between different skills, notably the interactions between phonology and morphology in children's development.

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Appendices

Appendix 1: DVIQ Production of morphology and syntax

1. Αυτό το κορίτσι διαβάζει. Αυτά τα κορίτσια **(παίζουν)**.	*This girl is reading. These girls (are playing)* plural – **simple present**
2. Αυτή είναι μια πάπια. Αυτές είναι τέσσερις **(γάτες).**	*This is a duck, these are four* ***(cats)*** **feminine plural**
3. Η γάτα είναι κάτω από το κρεβάτι. Η γάτα είναι (πάνω στο κρεβάτι).	*This cat is under the bed, this cat is* ***(on the bed)*** **adverb+ article +noun**
4. Αυτό το σκυλί είναι μέσα στο σπιτάκι. Αυτό το σκυλί είναι (έξω από το σπιτάκι).	*This dog is in the house, this dog is* ***(out of the house*****) adverb +article + noun**
5. Ο σκύλος είναι δικός του. Η κιθάρα είναι **(δική της).**	*The dog is his, the guitar is* ***(hers)*** **pronoun genitive**
6. Το αυτοκίνητο προχωράει προς εμένα. Το μηχανάκι προχωράει **(προς εσένα).**	*The car is coming towards me, the bicycle is coming* ***(towards you)*** **preposition + pronoun**
7. Αυτός είναι ο σκύλος του. Αυτή είναι (η γάτα της).	*This is his dog, this is* (***hers cat*****) noun +pronoun fem. genitive**
8. Αυτή είναι η μπλούζα του κοριτσιού. Αυτό είναι το μπουφάν **(του αγοριού).**	*This is the blouse the girl's, this is the jacket* ***(the boy's)*** **noun genitive**
9. Το κορίτσι προσφέρει λουλούδια σ'αυτόν.Το κορίτσι προσφέρει λουλούδια **(σ'αυτήν).**	*The girl is offering flowers to him. The girl is offering flowers to* ***(her)*** **preposition +pronoun fem acc**
10. Αυτή είναι μια κάλτσα. Είναι άσπρη. Αυτός είναι ένας σκούφος **(είναι μαύρος).**	*This is a sock (fem). It is white. This is a hat, it is* ***(black)*** **masc**
11. Εγώ γράφω.Εσύ κορίτσι (διαβάζεις).	*I write. You girl* ***(read)*** **2nd sing present**

12. Ποιος κοιμάται; Αυτή κοιμάται. Ποιοι τραγουδούν; (Αυτές τραγουδούν).	*Who is sleeping? She is sleeping who is singing?* ***(they are singing)*** **femine + verb 3rd pl pres**ent
13. Ποιο μωρό κλαίει; Αυτό το μωρό κλαίει. Ποιοι άνδρες γελούν; (αυτοί οι άνδρες γελούν).	*Which baby is crying? This baby which men are laughing****? (These men)*** **Masc pl**
14. Αυτή φροντίζει τον εαυτό της στον καθρέφτη. Αυτός βλέπει (τον εαυτό του στον καθρέφτη	*She is seeing herself in the mirror.* *He is seeing* ***(himself in the mirror)***
15. Αυτό είναι ένα μωρό. Το μωρό προσπαθεί να περπατήσει. Αυτό είναι ένα κορίτσι. Το κορίτσι (προσπαθεί να σκαρφαλώσει στο βράχο).	*This is a baby. The baby is trying to walk. This is a girl, the girl* ***(is trying to climb the rock)***
16. Αυτό είναι ένα φόρεμα. Αυτή έραψε το φόρεμα. Αυτές είναι πατάτες. Αυτός **(τηγάνισε τις πατάτες).**	*This is a dress. She made the dress. These are potatoes. He****(fried the potatoes*)** **verb 3rd sing, simple past**
17. Αυτός θέλει να φάει γιατί πείνασε. Αυτός θέλει να πιει νερό γιατί **(δίψασε).**	*He wants to eat because he is hungry.* *He wants to drink because* ***(He is thirsty)***
18. Αυτή τη γάτα τη ζωγράφισε το παιδί. Και αυτές τις γάτες (τις ζωγράφισε το παιδί).	*This cat (that) draw the child.* *And these cats* ***(them draw the child)***
19. Το παιδί παίζει. Το παιδί θα παίξει. Το παιδί γράφει. Το παιδί **(θα γράψει).**	*The boy plays. The boy will play* *The boy writes. The boy* ***(will write)*** **verb, 3rd p, future**
20. Το κορίτσι βγαίνει από το αυτοκίνητο. Αυτό είναι το αυτοκίνητο από το οποίο το κορίτσι **(βγήκε).**	*This girl is coming out of the car.* *This is the car from which the girl* ***(came out)*** **irregular past tense**
21. Η κυρία αγόρασε ανεμιστήρα. Νομίζει ότι θα κάνει ζέστη. Το κορίτσι αγόρασε ομπρέλα. Νομίζει **(ότι θα**	*The lady bought fun. Thinks that it will be hot. The girl bought umbrella. Thinks that It* ***will rain*** **(future)**

βρέξει).	
22. Το κορίτσι ζυγίζεται. Τα αγόρια (ζυγίζονται).	*The girl is waiting herself.* *The boys are* ***(waiting themselves).*** **Passive voice 3rd pl, Present**
23. Αυτός είναι ένας μανάβης. Αυτοί είναι (δυο μανάβηδες).	*This is a grocery man.* *These are* ***(two grocery men)*** **irregular plural**
24. Τα παιδιά σχόλασαν και φεύγουν από το σχολείο για το σπίτι.Οι διακοπές τελείωσαν και τα παιδιά πάνε **(από το νησί στην πόλη/ στο χωριό/στο σπίτι τους).**	*The children finished school and go to home)* *Holidays finished and the children go* ***(from island to town / home)***

Appendix 2: Comprehension of morphology and syntax

1. το κορίτσι διαβάζει	*1. The girl is reading*
2. το παιδί είναι κάτω απ'το τραπέζι	*2. The child is under the table*
3. ένα πιάτο με ζεστό φαγητό	*3. A plate with hot food*
4. το παιδί φοράει το πιο φαρδύ παντελόνι	*4. The child is wearing the more loose trousers*
5. το ψηλότερο δέντρο	*5. The highest tree*
6. τα παιδιά κολυμπούν	*6. The children are swimming*
7. τα παιδιά ταΐζουν τις πάπιες	*7. The children are making the ducks eat*
8. ο άνδρας άνοιξε την πόρτα	*8. The child is crying because his mother shouted at him*
9. το παιδί κλαίει γιαΤι η μαμά του το μάλωσε	*9. The girl gives the flowers to its mother*
10. το κορίτσι δίνει λουλούδια στη μητέρα του	*10. She reads and he sleeps*
11. αυτή διαβάζει και αυτός κοιμάται	*11. The one that is reading the paper is wearing glasses*
12. αυτός που διαβάζει εφημερίδα φοράει γυαλιά	*12. The girl is playing tennis*
13. πού παίζει τέννις το κορίτσι;	*13. The girl with the hair band is holding a basket*
14. το κορίτσι με την κορδέλα κρατάει ένα καλάθι	*14. The boy is not in the car*
15. το αγόρι δεν είναι μέσα στο αυτοκίνητο	*15. Don't smoke*
16. μην καπνίζετε	*16. The boy will eat the cake*
17. το παιδί θα φάει την τούρτα	*17. The man opened the door*
18. το παιδί θέλει να κοιμηθεί	*18. The child wants to sleep*
19. το παιδί ΜΠΟΡΕΙ να φτάσει το βάζο	*19. The child CAN reach the vase*
20. το βιβλίο σκίζεται από το κορίτσι	*20. The book is teared by the girl*
21. το αγόρι σπρώχνεται από το κορίτσι	*21. The boy is pushed by the girl*
22. το κορίτσι έδειξε το σκύλο στη μητέρα του	*22. The girl showed the dog to its mother*
23. το αγόρι βλέπει ένα κορίτσι που οδηγεί ένα ποδήλατο	*23. The boy sees a girl that drives a bicycle*
24. το πουλί πετάει προς το δέντρο	*24. The bird flyes to the tree*
25. το παιδί είναι ανάμεσα στο τραπέζι και	*25. The child is between the table and the chair*

την καρέκλα 26. το ποτήρι είναι μισογεμάτο 27. το πυκνότερο δάσος 28. τα παιδιά αγκαλιάζονται 29. αυτός που κρατάει το βιβλίο κάθεται στο παγκάκι 30. το παιδί δεν έκρυψε το παιχνίδι του 31. ο άνδρας κρεμάει την κορνίζα με τα λουλούδια	*26. The glass is half full* *27. The forest that has the most trees* *28. The children are hugging each other* *29. The one that holds the book sits on the bench* *30. The child didn't hid his toy* *31. The man is hugging the photo with the flowers*

Appendix 3: Sentence repetition

ˈðɛn ˈðɟɐvɐsɐ tɐ mɐˈθimɐˌtɐ mu	*I did not do my homework*
o ɐðɛɾˈfos tis mɐˈɾiɐs ˈinɛ ˈfilos mu	*Mary's brother is my friend*
tɐ çoniˈsmɛnɐ vuˈnɐ ˈinɛ oˈɾɛɐ	*(snowed) mountains are beautiful*
i mɐˈɾiɐ koliˈbɐi cɛ ˈpɛzi ˈvolɛi	*Marry swims and plays volleyball*
noˈmizi ˈoti ˈinɛ ˈɛksipni	*(She) thinks that (she) is smart*
o ˈɟɐnis ˈθɛli nɐ cimiˈθi	*John wants to sleep*
pços foˈnɐzi	*Who is shouting?*
tɐ ˈɛfɐɣɐ ˈolɐ tɐ ɣliˈkɐ	*The (I) ate all the sweets.*
pços ˈipɛ i mɐˈmɐ ˈoti ˈɛfɐɟɛ to ɣliˈko	*Who did mum say that ate the sweet?*
ðɛn ˈɛçi ðɟɐˈvɐsi ɐˈkomi ɛfimɛˈɾiðɐ	*(-3rd Person Sing) Has not read the paper yet*
ˈoli i ˈðɐskɐli ˈɛfiɣɐn ɟɐ to ˈspiti	*All the teachers left for home*
ɐˈpo ˈɐvɾio θɐ ˈsikonomɛ stis ˈɛksi	*From tomorrow I will be waking up at 6 (hours)*
min ksɛˈxɐsis nɐ tus to θiˈmisis	*Don't forget to remind them that*
tis ðoˈcimɐsɐ ˈolɛs tis kɐɾɐˈmɛlɛs	*I tried all the candies*
o ˈɟɐnis ˈfɛnɛtɛ nɐ ɐɣɐˈpɐi poˈli tɐ ˈzoɐ	*John seems to love the animals very much*
ˈkɐnɛ ˈoti boˈɾis nɐ ton voiˈθisis	*Do anything you can to help him.*

Appendix 4: Blending task

The target word is presented in bold	
puˈli - oˈbrɛlɐ - çɛˈlonɐ - kliˈði	*Bird – umbrella – turtle – key*
stɛˈfeni - **buˈkɐli** - kuˈðuni - bɐˈloni	*wreath – bottle – bell – balloon*
kuˈtɐli - ciˈθɐrɐ - **kɐˈɾevi** - kɐˈnɐtɐ	*Spoon – guitar – ship – jug*
mɐˈçɛri **- ɐˈstɛri** - ˈɐɟirɐ - ɐˈxlɐði	*Knife – star – anchor –pear*
p͡siˈɟio - kɐˈɾevi - **viˈvlio** - θrɐˈɲio	*Fridge – ship – book – desk*
kɐˈrot͡si - koˈrit͡si - pɛˈt͡sɛ tɐ - **pɐˈput͡si**	*Trolley – girl – towel – shoe*
ˈɛlɐto - ˈɐloɣo - **ɛˈlɐfi** - ˈpɛtɐlo	*Tree – horse – deer - petal*
ˈmɐskɐ - **ˈvɐrkɐ** - ˈturtɐ - ˈportɐ	*Mask – boat – cake – door*
ˈkuklɐ - ˈskupɐ - ˈbɐlɐ - **ˈskɐlɐ**	*Doll – broom – ball – ladder*
sfiˈri - sciˈli - **spɐˈθi** - ˈspiti	*Hammer – dog- sword – house*

Appendix 5: procedure followed for the interrater reliability scoring

A qualified SLT was asked to score approximately 10% of data collected at T1 as presented in Table 0-1. Prior to scoring she was given the scoring guidelines and along with the experimenter scored data from another child to ensure that the same procedure was followed and that minor distortions such as /s/ lisping production were treated similarly. The procedure followed for each task is presented in detail in the next sections.

Table 0-1 Selectivesample for interrater reliability

Data collected	Test battery	Reliability measurement 8 children
Real word repetition: 60 items	2 blocks phonological x 15 2 blocks morphological x 15	Block A x 15 Block B x 15
Nonword repetition: 60 items	2 blocks phonological x 15 2 blocks morphological x 15	Block B x 15 Block A x 15
Polysyllabic words: 21 items Polysyllabic nonwords: 21 items	3 blocks x 7 3 blocks x7	Block A x 7 Block B x 7
Naming	7 polysyllabic words + as many as below cut off criterion (5 consecutive semantic mistakes)	7 + X
Total at T1: **6156** repetition items +naming	Each child 162 repetition items + naming	**592** items **9,6 %** of items + naming

For repetition tasks:

The second rater, a qualified SLT, was given

- the target words written in Greek orthographically
- the non-words transcribed phonetically
- the number of phonemes contained in each stimulus
- children's recordings with an identification code for the child and the task.

In order to score the productions she was asked to:

- listen to each block and transcribe phonetically the children's production next to each stimulus
- score each production as accurate or not
- count the number of inaccurate phonemes in each inaccurate production
- give a total score of words and phonemes judged as incorrect

The researcher compared the scores given by herself and the second SLT for each block for the total number of words judged as incorrect and the total number of phonemes judged as incorrect.

For the naming task:

A qualified STL was given

- The target words written in Greek orthographically
- The children's recordings with an identification code for the child

In order to score the productions she had to:

- Listen to the recordings
- Transcribe children's productions one by one
- If the production of a word is not the semantic target s/he will write in Greek what s/he thinks the semantic target was
- Score each production as phonologically accurate or not, even if the child made a semantic mistake
- Count the number of inaccurate phonemes for every word that was phonologically inaccurate.
- Give a total score of words judged as phonologically incorrect and phonemes judged as inaccurate

The researcher compared the scores given by herself and the second SLT for each block for the total number of words judged as incorrect and the total number of phonemes judged as incorrect.

For the phoneme segmentation task

A qualified SLT was given the recordings of eight children

- She had to transcribe the words and indicate the segmentations that there where in each word
- She had to score according to the number and type of segmentations

The researcher compared the scores given by herself and the second SLT for the number of segmentations per word and the total segmentation score.

For the DVIQ production task

A qualified SLT was given the recordings of eight children

- She had to listen to the recordings and write orthographically the response to each test question
- She had to score according to the test guidelines

The researcher compared the scores given by herself and the second SLT for the number of responses scored as correct.

Appendix 6: Treated items on intervention phase 1

Phase 1: Phonological			
/s/ SIWI targets		/s/ SIWW targets	
[ˈsinɛfo]	*cloud*	[pɐˈtusɐ]	*paws*
[sɐˈɣoni]	*chin*	[ˈpisɐ]	*tar*
[sɐˈkɐci]	*jacket*	[ˈmɛsɐ]	*inside*
[sɐˈlɐmi]	*sausage*	[ˈvɾisi]	*tap*
[sɐˈpuni]	*soap*	[ˈmɛsi]	*middle*
[sɐliˈgɐɾi]	*snail*	[cɛˈɾɐsi]	*cherry*
[sɐˈloni]	*salon*	[niˈsi]	*island*
[ˈsɛlɐ]	*saddle*	[vɐsiˈʎɐs]	*king*
[ˈsɛlino]	*celery*	[miˈso]	*half*
[sɛˈdoni]	*sheet*	[ˈpiso]	*behind*
[siˈmɐɐ]	*flag*	[ˈpɾɐsino]	*green*
[siˈkoni]	*lifts*	[fɐˈsoli]	*bean*
[siˈɾopi]	*syrup*	[fɐˈɾɐsi]	*dust pan*
[siˈɾinɐ]	*siren*	[ˈpɾosopo]	*face*
[sioˈpi]	*silence*	[ɛkliˈsiɐ]	*church*
[sokoˈlɐtɐ]	*chocolate*	[ˈklosɐ]	*brood hen*
[ˈsolɐ]	*sole*	[kɐˈsɛɾi]	*cheese*
[ˈsobɐ]	*stove*	[puˈkɐmiso]	*shirt*
[suɾoˈtiɾi]	*strainer*	[ˈmɐɉisɐ]	*witch*
[sɛɾˈviɾi]	*serve*	[ˈcinisi]	*traffic*

Appendix 7: Treated items on intervention phase 2

Phase 2: Morphological			
/s/ SFWF Gen Fem Sing targets		**/s/ SFWF Acc Masc Pl targets**	
[vɛˈlonɐs]	*needle's*	[ˈkokoɾɛs]	*roosters*
[vɾoˈçis]	*rain's*	[ɛˈlɛfɐdɛs]	*elephants*
[kɐˈɾɛklɐs]	*chair's*	[ˈɐdɾɛs]	*men*
[ɐjɛˈlɐ⍰ɐs]	*cow's*	[ciniˈɣus]	*hunters*
[kukuˈvɐjɐs]	*owl's*	[cipuˈɾus]	*gardeners*
[ˈlɐbɐs]	*lamp's*	[ˈjiɣɐdɛs]	*giants*
[mixɐˈnis]	*engine's*	[ˈnɐnus]	*dwarfs*
[ˈbɐlɐs]	*ball's*	[piguˈinus]	*penguins*
[jiˈnɛkɐs]	*woman's*	[ˈcipus]	*gardens*
[ˈmitis]	*nose's*	[ˈcivus]	*cubes*
[çɛˈlonɐs]	*turtle's*	[ˈfilus]	*friends*
[pɛtɐˈlu⍰ɐs]	*butterfly's*	[fɐˈdɐɾus]	*soldiers*
[fɐˈnɛlɐs]	*jumper's*	[fɐˈkus]	*flashlights*
[ˈtuɾtɐs]	*cake's*	[ˈkobus]	*knots*
[ˈbotɐs]	*boot's*	[jɐˈtrus]	*doctors*
[ˈkuklɐs]	*doll's*	[ˈciklus]	*cycles*
[bɐˈnɐnɐs]	*banana's*	[ˈtixus]	*walls*
[foˈtçɐs]	*fire's*	[piˈlotus]	*pilots*
[ˈpɐpçɐs]	*duck's*	[ˈjɛɾus]	*old men*
[kɐɾɐˈmɛlɐs]	*candy's*	[ˈciknus]	*swans*

Appendix 8: Treated items on intervention phase 3

Phase 3: Phonological							
/sk/ WI		**/sk/ WI**		**/ks/ WI**		**/ks/WW**	
[ˈskɐci]	*chess*	[ˈfuskɐ]	*bubble*	[ˈksilo]	*wood*	[piksiˈ⍰ɐ]	*compass*
[ˈskɐlɐ]	*ladder*	[ˈ⍰isko]	*disk*	[ˈksino]	*scrape*	[ˈtokso]	*bow*
[ˈskupɐ]	*broom*	[ˈbɐscɛt]	*basket*	[ksɐˈplono]	*lie*	[ˈɛkso]	*outside*
[ˈsci]	*ski*	[kɐˈskol]	*scarf*	[ksiˈfiɐs]	*swordfish*	[ˈmiksɐ]	*snot*
[scɛˈpi]	*roof*	[ˈproskopo]	*scout*	[ksiˈpnɐo]	*wake up*	[ˈɛksi]	*six*
[sciˈni]	*tent*	[⍰ɐˈskɐlɐ]	*teacher*	[ˈksɛro]	*know*	[ɐˈmɐksi]	*car*
[sciˈɐ]	*shadow*	[ɐˈnɐscɛlɐ]	*backstroke*	[ksimɛˈroni]	*dawn*	[ɛksoˈçi]	*countryside*
[ˈskoni]	*dust*	[⍰ɐˈmɐscino]	*plum*	[ksɛno⍰oˈço]	*hotel*	[tɐˈksi]	*taxi*
[sciuˈrɐci]	*squirrel*	[fuˈskono]	*blow*	[ksiˈpoˈlito]	*barefoot*	[ˈtɐksi]	*classroom*
[skuˈfi]	*hat*	[ˈmuscɛmɐ]	*wet*	[ˈksi⍰i]	*vinegar*	[plɛˈksu⍰ɐ]	*strand*
[skotiˈnɐ]	*dark*						
[skuˈlici]	*worm*						
[ˈscɛftomɛ]	*thinking*						
[skulɐˈrici]	*earring*						
[skuˈpi⍰i]	*rubbish*						

Appendix 9: Treated items on Intervention phase 4

Phase 4: Morphological	
/ks/ in Simple past, WF	
['vuʎɐksɛ]	*sunk*
['ɛvɾɛksɛ]	*rained*
['fonɐksɛ]	*shouted*
['citɐksɛ]	*looked*
['vutiksɛ]	*dived*
['ɐdɛksɛ]	*withstood*
['ɛpɛksɛ]	*played*
['ʝɐlɛksɛ]	*chose*
['ɛplɛksɛ]	*knitted*
['ɛtɾɛksɛ]	*ran*
['ɛviksɛ]	*coughed*
['ɛ[illegible]iksɛ]	*showed*

Appendix 10: Probe assessment items

	treated		untreated		not targeted controls		distinctive controls	
Phase 1 Phonological /s/+vowel					controls /z/			
SIWI	[ˈsupɐ]	*soup*	[sokoˈlɐtɐ]	*chocolate*	[zɐˈcɐtɐ]	*jacket*		
	[ˈsinɛfo]	*cloud*	[sɐˈkulɐ]	*bag*	[ˈzɐxɐri]	*sugar*		
	[sɐliˈgɐri]	*snail*	[suˈvlɐci]	*skewer*	[ˈzoɐ]	*animals*		
SIWW	[cɛˈrɐsi]	*cherry*	[ˈmɛlisɐ]	*bee*	[ˈvɐzo]	*vaze*		
	[puˈkɐmiso]	*shirt*	[musiˈci]	*music*	[kuˈzinɐ]	*kitchen*		
	[ˈmɐjisɐ]	*witch*	[tileˈorɐsi]	*TV*	[mɛˈzurɐ]	*meter*		
Phase 2 Morphological /s/ Word Final					/s/nominative		genitive	
/s/SFWF feminine genitive sing	[çɛˈlonɐs]	*turtle's*	[oˈbrɛlɐs]	*umbrela*	[ˈmɛlisɛs]	*bees*	[moˈru]	*baby's*
	[kukuˈvɐjɐs]	*owl's*	[ˈkotɐs]	*hen*	[ˈbluzɛs]	*blouzes*	[kɐˈpɛlo]	*hat's*
	[ɐjɛˈlɐ□ɐs]	*cow's*	[ˈɣɐtɐs]	*cat*	[oˈbrɛlɛs]	*umberelas*	[ˈmilu]	*apple's*
/s/SFWF masculine accusative pl	[ɛˈlɛfɐdɛs]	*elephants*	[kɐrxɐˈriɛs]	*sharks*	[pɐpɐˈɣɐlos]	*parrot*	[pɐpɐˈɣɐlon]	*parrots'*
	[ˈkokorɛs]	*roosters*	[ˈmɐjirɛs]	*cooks*	[ˈlikos]	*woolf*	[ˈlikon]	*woolves's*
	[ˈɐdrɛs]	*men*	[ɐɛˈtus]	*eagles*	[lɐˈɣos]	*rabbit*	[lɐˈɣon]	*rabbits's*
Phase 3 Phonological clusters /sk/, /ks/							/tr/ cluster	
/sk/ WI	[ˈskɐlɐ]	*ladder*	[ˈskɐvi]	*digs*	[stɐˈfili]	*grape*	[ˈtrɛno]	*train*
	[ˈskɐci]	*chess*	[skɐˈdzoçiros]	*hedgehog*	[ˈstomɐ]	*mouth*	[ˈtrɛçi]	*run*
	[skuˈlici]	*worm*	[ˈscilos]	*dog*	[stɛˈfɐni]	*crown*	[ˈtroi]	*eat*
/sk/WW	[ˈproskopo]	*scout*	[voˈskos]	*shepherd*	[ˈfustɐ]	*skirt*	[jɐˈtros]	*doctor*
	[kɐˈskol]	*scarf*	[biˈskoto]	*biscuit*	[ɐstiˈnomos]	*policeman*	[ˈvɐtrɐxos]	*frog*
	[fuˈskono]	*blow*	[ˈmɐskɐ]	*mask*	[muˈstɐci]	*mustache*	[ˈcitrino]	*yellow*
/ks/ WI	[ksɐˈplono]	*lie*	[ksɛciˈnɐo]	*start*	[ˈpsɐri]	*fish*		
	[ksiˈfiɐs]	*swordfish*	[ˈksifos]	*sword*	[psɐˈli□i]	*scissors*		
	[ˈksilo]	*wood*	[ksiˈrɐfi]	*razor*	[ˈpsino]	*grill*		
/ks/ WW	[ɛksoˈçi]	*countryside*	[ˈɐmɐksɐ]	*carriage*	[ɐˈpopsɛ]	*tonight*		
	[ˈmiksɐ]	*snot*	[ˈɐniksi]	*spring*	[ˈjipso]	*plaster*		
	[ɐˈmɐksi]	*car*	[mɐksiˈlɐri]	*pillow*	[tɐˈpsi]	*pan*		
Phase 4 Morphological /ks/ / simple past morpheme					controls /ps/		passive	
	[ˈ□jɐlɐksɛ]	*chose*	[ˈpɛtɐksɛ]	*threw*	[ˈɐnɐpsɛ]	*lit*	[ciˈmɐtɛ]	*is sleeping*
	[ˈfonɐksɛ]	*shouted*	[ˈɐniksɛ]	*opened*	[ˈɛkopsɛ]	*cut*	[ˈplɛnɛtɛ]	*is washed*
	[ˈɛpɛksɛ]	*played*	[ˈtiliksɛ]	*wrapped*	[ˈɛvɐpsɛ]	*painted*	[xtɛˈnizɛtɛ]	*is combed*

Appendix 11: Short session plan for intervention phase 1

Intervention Phase 1 (6 sessions)

Focus Phonological - /s/ SIWI, SIWW position

	Target			Level	Phonotactic structure	Model provided	Cues provided
Session 1	A	Imitation	/s/	Single phoneme	C	Yes	Yes (visual – tactile as appropriate)
	B	Imitation	/s/	Syllables	CV, VCV, VC	Yes	Yes (visual – tactile as appropriate)
	C	Imitation	/s/	Single word	CV WISI position	Yes	Yes (visual – tactile as appropriate)
Session 2	A	Production	/s/	Syllable	CV, VCV, VC	Once	As Corrective feedback
	B	Spontaneous Production	/s/	Single word	CV WISI position	No	Visual cues
	C	Imitation	/s/	Single word	CV WWSI position	Yes	Yes (visual – tactile as appropriate)
Session 3	A	Aud D	/s/ - own	Syllable	CV and VCV		Visual contact
	B	Spontaneous Production	/s/	Single word	CV WISI position	No	As corrective feedback
	C	Spontaneous production	/s/	Single word	CV WWSI position	No	Yes (visual – tactile as appropriate)
Session 4	A	Aud D	/s/ - own	Syllable	CV, VCV, VC		As corrective feedback
	B	Mispr Jment	/s/ - own	Single word	CV WISI position		As corrective feedback
	C	Spontaneous production	/s/	Single word	CV WWSI position	No	As corrective feedback
Session 5	A	Mispr Jment	/s/ - own	Single word	CV WWSI position		As corrective feedback
	B	Imitation	/s/	Sentence	CV WISI position	Yes	As corrective feedback
	C	Imitation	/s/	Sentence	CV WWSI position	Yes	As corrective feedback
Session 6	A	Production	/s/	Sentence	CV WISI position	No	As corrective feedback
	B	Production	/s/	Sentence	CV WWSI position	No	As corrective feedback
	C	Onset detection (post box)	/s/ - own*	Word	CV WISI position		

*if child substitutes /s/ for another Greek phoneme

Appendix 12: Short session plan for Intervention phase 2

Intervention Phase 2 (6 sessions)

Focus Morphological - /s/ SFWF position

	Target			Level	Structure	Morphological element	Model provided	Cues provided
Session 1	A	Imitation	/s/	Syllable	VC		Yes	Yes (visual – tactile as appropriate)
	B	Imitation	/s/	words	VC – SFWF	Gen fem sing (mum's)	Yes	Yes (visual – tactile as appropriate)
	C	Aud D	/s/ - own	syllable	VC			Yes (visual – tactile as appropriate)
Session 2	A	Production	/s/	Syllable	VC		No	As corrective feedback
	B	Production	/s/	words	VC – SFWF	Gen fem sing (mum's)	No (elicited)	Yes (visual – tactile as appropriate)
	C	Immitation	/s/ - own	words	VC – SFWF	Acc masc pl (doctors)	Yes	Yes (visual – tactile as appropriate)
Session 3	A	Aud D Coda	/s/	words	...VC vs ...V	Gen vs Nom Fem		As corrective feedback
	B	Production	/s/	words	VC – SFWF	Gen fem sing (mum's)	No (elicited)	As corrective feedback
	C	Production	/s/	words	VC – SFWF	Acc masc pl (doctors)	No	Yes (visual – tactile as appropriate)
Session 4	A	Aud D Coda	/s/	words	...VC vs ...V	Gen Sing vs Acc Pl Masc		As corrective feedback
	B	Mispr Jment	/s/	words	...VC vs ...V	Gen fem sing (mum's)		As corrective feedback
	C	Production	/s/	words	VC – SFWF	Acc masc pl (doctors)	No	As corrective feedback
Session 5	A	Mispr Jment	/s/	words	...VC vs ...V	Acc masc pl (doctors)		As corrective feedback
	B	Immitation	/s/	sentence	VC – SFWF	Gen fem sing (mum's)	Yes	As corrective feedback
	C	Immitation	/s/	sentence	VC – SFWF	Acc masc pl (doctors)	Yes	As corrective feedback
Session 6	A	Production	/s/	sentence	VC – SFWF	Gen fem sing (mum's)	Yes	As corrective feedback
	B	Production	/s/	sentence	VC – SFWF	Acc masc pl (doctors)	Yes	As corrective feedback

Appendix 13: Short sessions plan for intervention phase 3

Intervention Phase 3 (7 sessions)

Focus Phonological - /sk/ initial, medial and /ks/ initial, medial

	Target			Level	Phonotactic structure	Model provided	Cues provided
Session 1	A	Imitation	/sk/	syllable	CCV, VCCV	Yes	Yes (visual – tactile as appropriate)
	B	Imitation	/sk/	word	CCV, WISI	Yes	Yes (visual – tactile as appropriate)
	C	Imitation	/sk/	word	CCV, WWSI	Yes	Yes (visual – tactile as appropriate)
Session 2	A	Aud D	/sk/-	Syllable	CCV, VCCV,		As Corrective feedback
	B	Production	/sk/	word	CCV, WISI	No	Yes (visual – tactile as appropriate)
	C	Production	/sk/	word	CCV, WWSI	No	Yes (visual – tactile as appropriate)
Session 3	A	Spontaneous Production	/sk/	word	CV WISI position	No	As corrective feedback
	B	Spontaneous production	/sk/	word	CV WWSI position	No	As corrective feedback
	C	Mispr Jment	/sk/ -	word	CV WISI position		As corrective feedback
	D	Mispr Jment	/sk/ -	word	CV WWSI position		As corrective feedback
Session 4	A	Imitation	/sk/	Sentence	CV WISI position	Yes	As corrective feedback
	B	Imitation	/sk/	Sentence	CV WWSI position	Yes	As corrective feedback
	C	Imitation	/ks/	syllable	CCV, VCCV	Yes	Yes (visual – tactile as appropriate)
	D	Imitation	/ks/	word	CCV, WISI	Yes	Yes (visual – tactile as appropriate)
	E	Imitation	/ks/	word	CCV, WWSI	Yes	Yes (visual – tactile as appropriate)
Session 5	A	Production	/ks/	word	CCV, WISI	No	Yes (visual – tactile as appropriate)
	B	Production	/ks/	word	CCV, WWSI	No	Yes (visual – tactile as appropriate)
	C	Aud D	/ks/ -own /ks/ -/sk/- /s/	Syllable	CCV, VCCV,		As Corrective feedback
Session 6	A	Imitation	/ks/	Sentence	CV WISI position	Yes	As corrective feedback
	B	Imitation	/ks/	Sentence	CV WWSI position	Yes	As corrective feedback
	C	Mispr Jment	/ks/ - own	word	CV WISI position		As corrective feedback
	D	Mispr Jment	/ks/ - own	word	CV WWSI position		As corrective feedback
Session 7	A	Production	/ks/	Sentence	CV WISI position	No	As corrective feedback
	B	Production	/ks/	Sentence	CV WWSI position	No	As corrective feedback
	C	Production	/sk/	Sentence	CV WISI position	No	As corrective feedback
	D	Production	/sk/	Sentence	CV WWSI position	No	As corrective feedback

Appendix 14: Short session plan for intervention Phase 4

Intervention Phase 4 (5 sessions)

Focus Morphological - /ks/ in past tense production

		Target		Level	Structure	Morphological element	Model provided	Cues provided
Session 1	A	Imitation	/ks/	words	CCV – SWWF	Past tense	Yes	Yes (visual – tactile as appropriate)
Session 2	A	Production	/ks/	words	CCV – SWWF	Past tense	No	Yes (visual – tactile as appropriate)
	B	Aud.D (same – diff)	/ks/-own	words	CCV – SWWF	Past tense		As corrective feedback
Session 3	A	Production	/ks/	words	CCV – SWWF	Past tense	No	As corrective feedback
	B	Mispr Jment	/ks/	words	CCV – SWWF	Past tense		As corrective feedback
Session 4	A	Aud D		words		Past - present		As corrective feedback
	B	Imitation	/ks/	sentence	CCV – SWWF	Past tense	Yes	As corrective feedback
Session 5	A	Production	/ks/	sentence	CCV – SWWF	Past tense	No	As corrective feedback

Appendix 15 Detailed session Plan: Phase 1(focus phonological): Session1

1st Activity: Target: Lower level articulation: The production of /s/ is isolation

i. Stimuli: C /s/

ii. Materials: mirror, snake toy

iii. Procedure: The therapist will provide instructions on the positioning of articulators and will model the production of the target phoneme /s/. The child will be asked to imitate the sound after the therapist.

iv. Feedback: If the phoneme is produced correctly the therapist will move on the snake. If the child has difficulty in producing the target the therapist will provide instructions on the correct positioning of the articulators as appropriate to the child's mistake.

v. Techniques: there will be visual contact with the therapist and a mirror for the child to observe his/ her mouth. Tactile information i.e. feeling of the airstream if necessary.

vi. Number of items: 10 times (therapist modelling and child imitating)

vii. Criterion: 7/10 times correct

2nd Activity: Target: Lower level articulation: The production of /s/ in syllables

i. Stimuli: CV syllables /s/+/ɐ,ɛ,i,o,u/.

ii. Materials: mirror, snake toy

iii. Procedure: The therapist will model the production of the target phoneme /s/ in CV and syllables with each of the Greek vowels /ɐ,ɛ,i,o,u/. The child will be asked to imitate each syllable after the therapist.

iv. Feedback: If the phoneme is produced correctly the therapist will move on the snake. If the child has difficulty in producing the target the therapist will provide instructions on the correct positioning of the articulators as appropriate to the child's mistake and will model the syllable again.

v. Techniques: there will be visual contact with the therapist and a mirror for the child to observe his/ her mouth. Tactile information i.e. feeling of the airstream if necessary.

vi. Number of items: Each vowel repeated 5 times (therapist modelling and child imitating) Total 25 syllables

vii. Criterion: 3/5 for each vowel correct

3rd Activity: Target: Motor programming: The production of /s/ in WISI position of words

i. Stimuli: words with /s/in WISI position, CV structure of the first syllable

ii. Materials: mirror, snake toy, pictures of words /s/ WISI

iii. Procedure: The therapist will present pictures one by one and name each picture. If the child is not familiar with the word, the therapist will explain the word meaning. The child will be asked to repeat each target word after the therapist.

iv. Feedback: If the target phoneme is produced correctly in SIWI position the therapist will move on the snake. If the child has difficulty in producing the target the therapist will provide instructions on the correct positioning of the articulators as appropriate to the child's mistake and will model the word again.

v. Techniques: there will be visual contact with the therapist and a mirror for the child to observe his/ her mouth. Tactile information i.e. feeling of the airstream if necessary.

vi. Number of items:20

vii. Criterion: 80% accuracy

Appendix 16 Detailed session Plan Phase 1 (focus phonological): Session 2

1st Activity: Target: Lower level articulation: The production of /s/ in syllables

i. Stimuli: CV syllables /s/ + /ɐ,ɛ,i,o,u/.
ii. Materials: mirror, snake toy
iii. Procedure: The therapist will model the production of the target phoneme /s/ in CV syllables with each of the Greek vowels /ɐ,ɛ,i,o,u/. The therapist will model a syllable e.g. [sɐ] once and then the child will be asked to repeat this syllable five times.
iv. Feedback: If the phoneme is produced correctly in a syllable the therapist will move on the snake. If the child has difficulty in producing the target the therapist will provide instructions on the correct positioning of the articulators as appropriate to the child's mistake. If the child still has difficulty the therapist will model the syllable again.
v. Techniques: there will be a mirror for the child to observe his/ her mouth. If necessary as corrective feedback there will be visual contact with the therapist and tactile information i.e. feeling of the airstream.
vi. Number of items: Each vowel repeated 5 times (therapist modelling once and child imitating five times) Total 25 syllables
vii. Criterion: 3/5 for each vowel correct (excluding the first one)

2nd Activity: Target: Motor programming/ update of stored motor programmes: The production of /s/ in WISI position of words

i. Stimuli: words with /s/in WISI position, CV structure of the first syllable
ii. Materials: mirror, snake toy, pictures of words
iii. Procedure: The therapist will present pictures one by one and the child will be asked to name each picture with the new 'snake sound'. If the child is not able to recognize the picture, the therapist will describe the word meaning.
iv. Feedback: If the target phoneme is produced correctly in SIWI position the therapist will move on the snake. If the child has difficulty in producing the target the therapist will provide instructions on the correct positioning of the articulators as appropriate to the child's mistake. If the child still has difficulty in producing the word the therapist will model the word.
viii. Techniques: there will be a mirror for the child to observe his/ her mouth. If necessary as corrective feedback there will be visual contact with the therapist and tactile information i.e. feeling of the airstream.
v. Number of items:20
vi. Criterion: 80% accuracy

3rd Activity: Target: Motor programming: The production of /s/ in WWSI position of words

i. Stimuli: words with /s/in WWSI position, CV structure of the target syllable
ii. Materials: mirror, snake toy, pictures of words /s/ WWSI

iii. Procedure: The therapist will present pictures one by one and name each picture. If the child is not familiar with the word, the therapist will explain the word meaning. The child will be asked to repeat each target word after the therapist.
iv. Feedback: If the target phoneme is produced correctly in WWSI position the therapist will move on the snake. If the child has difficulty in producing the target the therapist will provide instructions on the correct positioning of the articulators as appropriate to the child's mistake and will model the word again.
v. Techniques: there will be visual contact with the therapist and a mirror for the child to observe his/ her mouth. Tactile information i.e. feeling of the airstream if necessary.
vi. Number of items:20
vii. Criterion: 80% accuracy

If the child is not able to reach criterion in one task the whole task will be repeated before continuing to the next task.

Appendix 17 Detailed session Plan Phase 2 (focus morphological): Session 3

1st Activity: Target: Auditory discrimination of feminine nouns between nominative and genitive case in singular number.

i. Stimuli: feminine nouns in nominative case (ending in a vowel) for example /ɐjɛˈlɐðɐ/ (*cow*) and feminine nouns in genitive case ending in a vowel + /s/ for example /ɐjɛˈlɐðɐs/ (*cow's*)
ii. Materials: 6 feminine nouns used to form 24 pairs, 12 same (both either in genitive or nominative case for example /ɐjɛˈlɐðɐ/-/ɐjɛˈlɐðɐ/) and 12 different (one genitive and one nominative, for example /ɐjɛˈlɐðɐ/-/ɐjɛˈlɐðɐs/). A Dragon toy with flags is used as reinforcement.
iii. Procedure: The therapist will say the two words of the pair and ask the child to decide if they were same or different. There will be no visual contact; the therapist will be sitting next to the child, covering her mouth.
iv. Feedback: If the child makes the correct decision the therapist will give a flag. If the child makes a mistake the therapist will repeat the pair with prolonged duration of /s/.
v. Techniques: if the child fails twice, there will be visual contact with the therapist and tactile information i.e. feeling of the airstream.
vi. Number of items:24
vii. Criterion: 80% accuracy

2nd Activity: Target: Elicited production of masculine nouns in accusative case in plural number

i. Stimuli: masculine nouns, to be used in accusative case plural ending in a vowel + /s/ for example /fɐˈkus/ *(flashlights*)
ii. Materials: pictures of 20 masculine nouns in plural, mirror
iii. Procedure: the therapist presents one picture at a time. The therapist says a carrier phrase (i.e. in this picture I can see...) without saying the object (that has to be a noun in the accusative case) for the child to complete with the target masculine noun in the accusative case of plural.
iv. Feedback: If the child produces the target noun, in the accusative case in plural with accurate production of /s/ the therapist moves on to the next picture. If the child fails to produce the accurate case (for example nominative instead of accusative) the therapist makes a commentary, to demonstrate that an object is required to complete the phrase and the accusative case should be used. If the child fails to produce /s/ final accurately, the therapist will provide instructions on the correct positioning of the articulators as appropriate to the child's mistake.
v. Techniques: there will be visual contact with the therapist and a mirror for the child to observe his/ her mouth. Tactile information i.e. feeling of the airstream may be used if necessary.
vi. Number of items:20
vii. Criterion: 80% accuracy

3rd Activity: Target: Elicited production of feminine nouns in genitive case in singular number

i. Stimuli: feminine nouns in genitive case ending in a vowel + /s/ for example /ɐjɛˈlɐðɐs/ (*cow’s*)
ii. Materials: pictures of 20 feminine nouns
iii. Procedure: the therapist presents one picture at a time. The therapist says a carrier phrase to elicit the production of the target noun in genitive case (for example, whose is this tail? This tail is ...)
iv. Feedback: If the child produces the target noun, in the genitive case in singular with accurate production of /s/ final the therapist moves on to the next picture. If the child fails to produce the accurate case (for example nominative instead of genitive) the therapist makes a commentary, to demonstrate that a possessive is required to complete the phrase and the genitive case should be used. If the child fails to produce /s/ final accurately, the therapist will provide corrective feedback. If the child fails to produce/s/ final accurately, the therapist will provide instructions on the correct positioning of the articulators as appropriate to the child’s mistake.
v. Techniques: there will be no visual cues.
vi. Number of items:20
vii. Criterion: 80% accuracy

Appendix 18 Ethical approval confirmation letter for the longitudinal study

The University Of Sheffield.

Department of Human Communication Sciences
31 Claremont Crescent
Sheffield S10 2TA UK

Head of Department
Professor Joy Stackhouse, PhD., F.R.C.S.L.T., C.Psychol., A.F.B.Ps.S

Telephone: +44 (0) 114 222 2418/ 2402/ 2405
International: +44 (0) 114 222 2418
Fax: +44 (0) 114 273 0547
Email: hcs-support@sheffield.ac.uk
http://www.shef.ac.uk/hcs

24th August 2011

Dear Eleftheria

Title: The development of speech processing and language acquisition in Greek speaking children

Thank you for your submission to the HCS Research Ethics Committee. The committee has reviewed your submission and supporting documents and grants you approval to commence the research.

We hope your project proceeds smoothly

Yours sincerely

[redacted]

Prof R Varley
Chair of HCS Ethics Committee

ETHICS REVIEWER'S COMMENTS FORM

This form is for use when ethically reviewing a research ethics application form.

1. Name of Ethics Reviewer:	Richard Body Silke Fricke Ben Rutter
2. Research Project Title:	Development of speech and language in Greek-speaking children
3. Principal Investigator (or Supervisor):	Eleftheria Geronikou
4. Academic Department / School:	HCS

5. I confirm that I do not have a conflict of interest with the project application

6. I confirm that, in my judgment, the application should:

Be approved:	Be approved with *suggested* amendments in '7' below: and/or	Be approved providing *requirements* specified in '8' below are met:	NOT be approved for the reason(s) given in '9' below:
✓			

7. Approved with the following suggested, optional amendments (i.e. it is left to the discretion of the applicant whether or not to accept the amendments and, if accepted, the ethics reviewers do not need to see the amendments):

8. Approved providing the following, compulsory requirements are met

9. Not approved for the following reason(s):

10. Date of Ethics Review: 30 October 2012

[redacted]