

8-24-2016

# English Morphological Development in Bimodal Bilingual Children: Deaf Children with Cochlear Implants and Hearing Children of Deaf Adults

Corina V. Goodwin  
corina.goodwin@uconn.edu

Follow this and additional works at: <https://opencommons.uconn.edu/dissertations>

---

## Recommended Citation

Goodwin, Corina V., "English Morphological Development in Bimodal Bilingual Children: Deaf Children with Cochlear Implants and Hearing Children of Deaf Adults" (2016). *Doctoral Dissertations*. 1221.  
<https://opencommons.uconn.edu/dissertations/1221>

English Morphological Development in Bimodal Bilingual Children: Deaf Children with  
Cochlear Implants and Hearing Children of Deaf Adults

Corina Vanessa Goodwin, PhD

University of Connecticut, 2016

This dissertation investigates the acquisition of English morphology in two bilingual populations: hearing American Sign Language (ASL)-English bilinguals and Deaf ASL-English bilinguals with cochlear implants (CIs). Such a study is important to not only help address more general theoretical questions about the role of input in language acquisition, but also to help establish expected outcomes in these populations vulnerable to over-diagnosis of language disorder. Spontaneous and elicited speech samples were used to determine accuracy rates in obligatory contexts for ten English morphemes (definite and indefinite determiner, progressive *-ing*, (un)contractible copula, (un)contractible auxiliary, regular plural, regular 3<sup>rd</sup> person present, and regular past tense), overall morphological accuracy and mean length of utterance (MLU). Results from the hearing bilinguals were remarkably similar to previous findings with monolingual children, although sometimes the bilinguals were at the lower end of the typical range. The results from the bilinguals with CIs were then compared to the hearing bilinguals because, other than the delayed exposure to spoken English before implantation, their language environments were very similar. The bilinguals with CIs showed dissociation between MLU and grammatical morpheme accuracy not seen in the bilingual comparison group or typical monolinguals. This was due to the fact that even at the lowest MLUs, morphological accuracy was high, suggesting that older children with

Corina Vanessa Goodwin – University of Connecticut, 2016

cochlear implants go through a developmental phase in which they speak telegraphically, like younger typical hearing children, yet possess relatively sophisticated morphological knowledge, unlike hearing children in the same developmental phase. Furthermore, results from both spontaneous and elicited speech showed that, while there were many similarities between the hearing bilinguals and those with CIs, the latter group is particularly susceptible to difficulties with the English plural (there was not enough data available to assess the past tense and 3<sup>rd</sup> person present). These difficulties could be due to the nature of hearing through a CI, or the delayed English language exposure.

English Morphological Development in Bimodal Bilingual Children: Deaf Children with  
Cochlear Implants and Hearing Children of Deaf Adults

Corina Vanessa Goodwin

B.A., Arizona State University, 2006

M.A., University of Connecticut, 2013

A Dissertation

Submitted in Partial Fulfillment of the

Requirements for the Degree of Doctor of Philosophy

at the

University of Connecticut

2016



Copyright by  
Corina Vanessa Goodwin

2016

ii

APPROVAL PAGE

Doctor of Philosophy Dissertation

English Morphological Development in Bimodal Bilingual Children: Deaf Children with  
Cochlear Implants and Hearing Children of Deaf Adults

Presented by

Corina Vanessa Goodwin, B.A, M.A.

Major Advisor \_\_\_\_\_  
Diane Lillo-Martin

Associate Advisor \_\_\_\_\_  
William Snyder

Associate Advisor \_\_\_\_\_  
Marie Coppola

University of Connecticut

2016

## ACKNOWLEDGEMENTS

First and foremost, I would like to thank the children and families that participated in this research. They have taught me so much about the amazing things people are capable of. Thank you to my advisor Diane Lillo-Martin for sparking my interest in this area of research. You were always patient and supportive, tolerating many a meeting interruption by babies, and later, toddlers. Thank you to my associate advisors William Snyder and Marie Coppola and my advisor-in-law, Letty Naigles for your support and guidance. I was very lucky to be accepted into such an excellent department and would like to thank all of the professors who taught me in any way during my stay at UConn, especially Jon Gajewski, Harry Van der Hulst, and Susi Wurmbrand.

I was also fortunate to be surrounded by warm and caring graduate students from all over the world and would especially like to thank Ting Xu, Lyn Tieu, Johnny Cheng and Tsuyoshi Sawada. My lab-mates Julia Adell, Kate Davidson, Kate Guerrera, Helen Koulidobrova, Mike Jacques, Katie Peirolo, & Vanessa Petroj made every day fun and stimulating. Thank you to all of the SLRDGers for the great conversations, feedback and support, especially Emily Carrigan, Deanna Gagne, and Russell Richie. Thank you to Doreen Simons and Sherry Powell for sharing your beautiful language (ASL) with me and making me think about the world in ways I never had before. And, of course, I owe a great debt of gratitude to my undergraduate advisors at ASU who began this great expansion of my world, particularly Don Homa, who helped me recognize my potential, and Susan Somerville, whose class on child language and drawing was the original impetus behind what I now consider my life's focus.

Last, but definitely not least, this work would never have been completed, nor this journey even begun, without my best friend and husband Anthony Goodwin. Thank you for giving me the courage to travel 2,000 miles from home and start this great undertaking. I'm quite sure neither of us really understood what we were getting into at the time, but I'm glad we did it! Finally, I should both apologize to and recognize my two children Felix and Sonora Goodwin. I'm sorry for all the times I was tired or distracted, but thank you for giving me the inspiration I needed to finish this dissertation!

This research was supported in part by Award Number R01DC009263 from the National Institutes of Health (National Institute on Deafness and Other Communication Disorders). The content is solely the responsibility of the author and does not necessarily represent the official views of the NIDCD or NIH. Support was also provided by awards from the Gallaudet Research Institute and from CHPq (Brazilian National Council of Technological and Scientific Development) Grant #200031/2009-0 and #470111/2007-0.

# TABLE OF CONTENTS

<b>CHAPTER 1: INTRODUCTION .....</b>	<b>1</b>
1.1 PURPOSE .....	1
1.2 WHY STUDY MORPHOLOGICAL DEVELOPMENT? .....	3
1.3 ORGANIZATION OF DISSERTATION .....	4
1.4 BILINGUALISM .....	5
1.4.1 <i>What is Bilingualism?</i> .....	5
1.4.2 <i>Language Development in Bilingual Children</i> .....	8
1.4.3 <i>Language Development in Bimodal Bilingual Children</i> .....	12
1.5 CHILDREN WITH COCHLEAR IMPLANTS .....	16
1.5.1 <i>What is a Cochlear Implant?</i> .....	16
1.5.2 <i>Language Development in Children with Cochlear Implants</i> .....	20
1.5.3 <i>What Factors Affect Outcome?</i> .....	23
1.5.4 <i>Language Development in Unimodal Bilingual Children with Cochlear Implants</i> .....	26
1.5.5 <i>Language Development in Bimodal Bilingual Children with Cochlear Implants</i> .....	29
<b>CHAPTER 2: MORPHOLOGICAL DEVELOPMENT IN HEARING BIMODAL BILINGUAL CHILDREN'S SPONTANEOUS SPEECH .....</b>	<b>31</b>
2.1 BACKGROUND .....	31
2.1.1 <i>Monolingual Morphological Development</i> .....	31
2.1.2 <i>Specific Language Impairment (SLI)</i> .....	36
2.1.3 <i>Bilingual Morphological Development</i> .....	38
2.1.4 <i>Bimodal Bilingual Morphological Development</i> .....	42
2.2 PREDICTIONS .....	44
2.3 METHOD .....	45
2.3.1 <i>Participants</i> .....	45
2.3.2 <i>Data Collection</i> .....	46
2.3.3 <i>Coding</i> .....	48
2.3.4 <i>Analyses</i> .....	50
2.3.5 <i>Reliability</i> .....	52
2.4 RESULTS .....	53
2.4.1 <i>Modality</i> .....	53
2.4.2 <i>Mean Length of Utterance</i> .....	57
2.4.3 <i>Overall Accuracy</i> .....	60
2.4.4 <i>Individual Morpheme Performance</i> .....	63
2.4.5 <i>Perceptual Salience Hypothesis</i> .....	69
2.4.6 <i>Section 2.4.6 Error Type Frequencies</i> .....	70
2.5 DISCUSSION .....	75
<b>CHAPTER 3: MORPHOLOGICAL DEVELOPMENT IN DEAF BIMODAL BILINGUAL CHILDREN WITH COCHLEAR IMPLANTS' SPONTANEOUS SPEECH .....</b>	<b>78</b>
3.1 BACKGROUND .....	78
3.1.1 <i>Morphological Development in Monolingual Children with Cochlear Implants</i> .....	78
3.1.2 <i>Acquisition of Variable or Inconsistent Input</i> .....	83
3.1.3 <i>Why Compare to Hearing Bimodal Bilinguals?</i> .....	85
3.2 PREDICTIONS .....	86

3.3 METHOD .....	87
3.3.1 Participants.....	87
3.3.2 Data Collection.....	88
3.3.3 Coding .....	89
3.3.4 Analyses.....	90
3.3.5 Reliability.....	90
3.4 RESULTS.....	91
3.4.1 Modality .....	91
3.4.2 Mean Length of Utterance.....	93
3.4.3 Overall Accuracy.....	97
3.4.4 Individual Morpheme Performance.....	102
3.4.5 Perceptual Salience Hypothesis.....	110
3.4.6 Error Type Frequencies.....	111
3.5 DISCUSSION .....	114
<b>CHAPTER 4: ELICITATION DATA .....</b>	<b>117</b>
4.1 BACKGROUND .....	117
4.2 PREDICTIONS .....	118
4.3 METHOD .....	118
4.3.1 Participants.....	119
4.3.2 Data Collection.....	121
4.3.3.....	123
4.3.4 Coding .....	123
4.3.5 Analyses.....	124
4.3.6 Reliability.....	124
4.4 RESULTS.....	125
4.4.1 MLU.....	125
4.4.2 Overall Accuracy.....	125
4.4.3 Individual Morpheme Performance.....	128
4.4.4 Perceptual Salience Hypothesis.....	129
4.4.5 Error Type Frequencies.....	131
4.4.6 Age of Implantation and Overall Accuracy.....	134
4.4.7 Comparing Longitudinal and Elicitation Data .....	134
4.5 DISCUSSION .....	135
<b>CHAPTER 5: CONCLUSION.....</b>	<b>139</b>
5.1 ENGLISH MORPHOLOGICAL DEVELOPMENT IN THE SPONTANEOUS SPEECH OF HEARING BIMODAL BILINGUAL CHILDREN .....	139
5.2 ENGLISH MORPHOLOGICAL DEVELOPMENT IN THE SPONTANEOUS SPEECH OF DEAF BIMODAL BILINGUAL CHILDREN WITH COCHLEAR IMPLANTS.....	141
5.3 ENGLISH MORPHOLOGICAL DEVELOPMENT IN THE ELICITED SPEECH OF HEARING AND DEAF WITH COCHLEAR IMPLANTS BIMODAL BILINGUALS.....	143
5.4 COMPARISON OF MORPHOLOGICAL DEVELOPMENT IN SPONTANEOUS AND ELICITED SPEECH OF BIMODAL BILINGUALS .....	144
5.5 LIMITATIONS OF THIS STUDY .....	145
5.6 IMPORTANCE OF THIS STUDY .....	146
5.7 FUTURE RESEARCH.....	147
<b>APPENDIX A: RULES USED TO CODED MLU.....</b>	<b>149</b>
<b>APPENDIX B: HEARING BIMODAL BILINGUALS' ERROR TYPE FREQUENCY FIGURES .....</b>	<b>150</b>

<b>APPENDIX C: DEAF BIMODAL BILINGUALS WITH CIS' ERROR TYPE FREQUENCY FIGURES..</b>	<b>155</b>
<b>APPENDIX D: VERBAL MORPHOLOGY CARDS .....</b>	<b>160</b>
<b>APPENDIX E: NARRATIVE PICTURES .....</b>	<b>165</b>
<b>REFERENCES.....</b>	<b>168</b>

## List of Tables

<i>Table 2.1 Order of Acquisition of Brown's 14 Morphemes .....</i>	<i>33</i>
<i>Table 2.2 Age of Acquisition of Brown's 14 Grammatical Morphemes.....</i>	<i>34</i>
<i>Table 2.3 Morphemes in Order from Most to Least Perceptually Salient.....</i>	<i>38</i>
<i>Table 2.4: SES Information for Hearing Bimodal Bilinguals.....</i>	<i>46</i>
<i>Table 2.5: Deaf Family Members of Hearing Bimodal Bilinguals.....</i>	<i>46</i>
<i>Table 2.6: Hearing Bimodal Bilinguals' Spontaneous Speech Sample Information.....</i>	<i>47</i>
<i>Table 2.7: Reliability Coding Results.....</i>	<i>53</i>
<i>Table 2.8: Variability in MLU Calculations.....</i>	<i>53</i>
<i>Table 2.9: Determiner Accuracy for Hearing Bimodal Bilinguals' English and ASL Target Sessions, Cantonese-English Bilinguals' English Sessions and One Monolingual English Child.....</i>	<i>56</i>
<i>Table 2.10: Language Modality for Hearing Bimodal Bilinguals' English and ASL Sessions.....</i>	<i>56</i>
<i>Table 2.11: Thordardottir's MLU Results.....</i>	<i>59</i>
<i>Table 2.12: Hearing Bimodal Bilinguals' MLU<sub>w</sub> at 36 and 60 months.....</i>	<i>59</i>
<i>Table 2.13: Hearing Bimodal Bilinguals' Age of Acquisition of Grammatical Morphemes .....</i>	<i>67</i>
<i>Table 2.14: Monolinguals' Age of Acquisition of Grammatical Morphemes.....</i>	<i>67</i>
<i>Table 2.15: Accuracy for Grammatical Morphemes at 3;00.....</i>	<i>68</i>
 <i>Table 3.1: Background Information for Deaf Bimodal Bilinguals .....</i>	 <i>87</i>
<i>Table 3.2: Deaf Family Members of Deaf Bimodal Bilinguals.....</i>	<i>87</i>
<i>Table 3.3: Deaf Bimodal Bilinguals' Spontaneous Speech Sample Information .....</i>	<i>89</i>
<i>Table 3.4: Hearing Bimodal Bilinguals' MLU<sub>w</sub> at 36 and 60 months .....</i>	<i>97</i>
<i>Table 3.5: Deaf Bimodal Bilinguals' MLU<sub>w</sub> at 36 and 60 months.....</i>	<i>97</i>
<i>Table 3.6: Deaf Bimodal Bilinguals' Age of Acquisition of Grammatical Morphemes .....</i>	<i>108</i>
<i>Table 3.7: Hearing Bimodal Bilinguals' Age of Acquisition of Grammatical Morphemes .....</i>	<i>108</i>
<i>Table 3.8: Monolinguals' Age of Acquisition of Grammatical Morphemes .....</i>	<i>110</i>
 <i>Table 4.1: Participant Information for Elicitation Study.....</i>	 <i>120</i>
<i>Table 4.2: Summary of Elicitation Study Participant Ages.....</i>	<i>120</i>
<i>Table 4.3: Form of Narrative Task Given to Each Participant .....</i>	<i>123</i>
<i>Table 4.4: Number of Utterances Used in Elicitation Study.....</i>	<i>124</i>
<i>Table 4.5: Elicitation MLU Results by Group .....</i>	<i>125</i>
<i>Table 4.6: Morphemes from Most to Least Perceptually Salient .....</i>	<i>130</i>



## List of Figures

Figure 1.1 Ear with Cochlear Implant (Source: NIH/NIDCD, 2016).....	18
Figure 1.2: Frequency Range and Amplitude of Speech Sounds (Source: MED-EL, 2013).....	20
Figure 2.1: Hearing Bimodal Bilinguals' Proportion of Morphemes in Bimodal Modality.....	54
Figure 2.2: Hearing Bimodal Bilinguals' Proportion of All Errors Produced Bimodally.....	55
Figure 2.3: Hearing Bimodal Bilinguals' Accuracy by Utterance Type.....	55
Figure 2.4: Hearing Bimodal Bilingual's MLU in Words by Chronological Age.....	58
Figure 2.5: Hearing Bimodal Bilinguals' MLU in Morphemes by Chronological Age.....	58
Figure 2.6: Hearing Bimodal Bilinguals' Overall Accuracy by Chronological Age.....	61
Figure 2.7: Overall Accuracy by MLU <sub>w</sub> for Hearing Bimodal Bilinguals.....	61
Figure 2.8: Hearing Bimodal Bilinguals' Overall Verb Accuracy by Chronological Age.....	62
Figure 2.9: Hearing Bimodal Bilinguals' Overall Plural Accuracy by Chronological Age.....	62
Figure 2.10: Hearing Bimodal Bilinguals' Overall Determiner Accuracy by Chronological Age.....	63
Figure 2.11: Hearing Bimodal Bilinguals' Accuracy with Progressive -ing.....	64
Figure 2.12: Hearing Bimodal Bilinguals' Accuracy with Regular Plurals.....	64
Figure 2.13: Hearing Bimodal Bilinguals' Accuracy with Determiners.....	65
Figure 2.14: Hearing Bimodal Bilinguals' Accuracy with Contractible Copulas.....	65
Figure 2.15: Hearing Bimodal Bilinguals' Accuracy with Contractible Auxiliaries.....	66
Figure 2.16: Hearing Bimodal Bilinguals' Accuracy by Morpheme in Order of Perceptual Salience at 3;00, 3;06 & 5;00.....	69
Figure 2.17: Ben's Overall Error Type Frequencies.....	73
Figure 2.18: Ben's Overall Verb Error Type Frequencies.....	73
Figure 2.19: Ben's Overall Plural Error Type Frequencies.....	74
Figure 2.20: Ben's Overall Determiner Error Type Frequencies.....	74
Figure 3.1: Deaf Bimodal Bilinguals' Proportion of Morphemes in Bimodal Modality.....	91
Figure 3.2: Deaf Bimodal Bilinguals' Proportion of All Errors Produced Bimodally.....	92
Figure 3.3: Deaf Bimodal Bilinguals' Accuracy by Utterance Type.....	93
Figure 3.4: Deaf Bimodal Bilinguals' MLU <sub>w</sub> by Chronological Age.....	94
Figure 3.5: Deaf and Hearing Bimodal Bilinguals' MLU <sub>w</sub> by Chronological Age.....	94
Figure 3.6: Deaf Bimodal Bilinguals' MLU <sub>m</sub> by Chronological Age.....	95
Figure 3.7: Deaf and Hearing Bimodal Bilinguals' MLU <sub>m</sub> by Chronological Age.....	95
Figure 3.8: Deaf Bimodal Bilinguals' Overall Accuracy by MLU <sub>w</sub> .....	96
Figure 3.9: Deaf Bimodal Bilinguals' Overall Accuracy by Chronological Age.....	98
Figure 3.10: Deaf and Hearing Bimodal Bilinguals' Overall Accuracy by Chronological Age.....	98
Figure 3.11: Deaf Bimodal Bilinguals' Overall Verb Accuracy by Chronological Age.....	99
Figure 3.12: Deaf and Hearing Bimodal Bilinguals' Overall Verb Accuracy by Chronological Age.....	99
Figure 3.13: Deaf Bimodal Bilinguals' Overall Plural Accuracy by Chronological Age.....	100
Figure 3.14: Deaf and Hearing Bimodal Bilinguals' Overall Plural Accuracy by Chronological Age.....	100
Figure 3.15: Deaf Bimodal Bilinguals' Overall Determiner Accuracy by Chronological Age.....	101
Figure 3.16: Deaf and Hearing Bimodal Bilinguals' Overall Determiner Accuracy by Chronological Age.....	101
Figure 3.17: Deaf Bimodal Bilinguals' Accuracy with Progressive -ing.....	102
Figure 3.18: Deaf and Hearing Bimodal Bilinguals' Accuracy with Progressive -ing.....	103
Figure 3.19: Deaf Bimodal Bilinguals' Accuracy with Regular Plurals.....	103
Figure 3.20: Deaf and Hearing Bimodal Bilinguals' Accuracy with Regular Plurals.....	104
Figure 3.21: Deaf Bimodal Bilinguals' Accuracy with Determiners.....	104
Figure 3.22: Deaf and Hearing Bimodal Bilinguals' Accuracy with Determiners.....	105
Figure 3.23: Deaf Bimodal Bilinguals' Accuracy with Contractible Copulas.....	105
Figure 3.24: Deaf and Hearing Bimodal Bilinguals' Accuracy with Contractible Copulas.....	106
Figure 3.25: Deaf Bimodal Bilinguals' Accuracy with Contractible Auxiliaries.....	106
Figure 3.26: Deaf and Hearing Bimodal Bilinguals' Accuracy with Contractible Auxiliaries.....	107

Figure 3.27: Bimodal Bilinguals' Accuracy by Morpheme in Order of Perceptual Salience at Age 5.....	111
Figure 3.28: Eli's Overall Error Type Frequencies .....	112
Figure 3.29: Eli's Overall Verb Error Type Frequencies.....	112
Figure 3.30: Eli's Overall Plural Error Type Frequencies.....	113
Figure 3.31: Eli's Overall Determiner Error Type Frequencies .....	113
Figure 4.1: Example Verbal Morphology Test Card.....	122
Figure 4.2: Elicitation Study Overall Accuracy by Group.....	126
Figure 4.3: Elicitation Study Overall Accuracy for Different Morpheme Types by Group .....	126
Figure 4.4: Elicitation Study Overall Accuracy without Pragmatic by Group Errors.....	127
Figure 4.5: Elicitation Study Overall Accuracy without Pragmatic Errors for Different Morpheme Types by Group .....	128
Figure 4.6: Elicitation Study Group Accuracy by Morpheme .....	129
Figure 4.7: Elicitation Study Accuracy by Morpheme in Order of Perceptual Salience at Age 5.....	130
Figure 4.8: Elicitation Study Overall Error Type Frequencies .....	132
Figure 4.9: Elicitation Study Overall Verb Error Type Frequencies .....	132
Figure 4.10: Elicitation Study Overall Plural Error Type Frequencies.....	133
Figure 4.11: Elicitation Study Overall Determiner Error Type Frequencies .....	133
Figure 4.12: Overall Accuracy by Age of Implant Activation .....	134
Figure 4.13: Overall Accuracy by Chronological Age Including All Data.....	135
Figure B.1: Lex's Overall Error Type Frequencies.....	150
Figure B.2: Tom's Overall Error Type Frequencies.....	151
Figure B.3: Lex's Overall Verb Error Type Frequencies.....	151
Figure B.4: Tom's Overall Verb Error Type Frequencies.....	152
Figure B.5: Lex's Overall Plural Error Type Frequencies.....	152
Figure B.6: Tom's Overall Plural Error Type Frequencies.....	153
Figure B.7: Lex's Overall Determiner Error Type Frequencies.....	153
Figure B.8: Tom's Overall Determiner Error Type Frequencies.....	154
Figure C.1: Gia's Overall Error Type Frequencies.....	155
Figure C.2: Nik's Overall Error Type Frequencies.....	156
Figure C.3: Gia's Overall Verb Error Type Frequencies.....	156
Figure C.4: Nik's Overall Verb Error Type Frequencies.....	157
Figure C.5: Gia's Overall Plural Error Type Frequencies.....	157
Figure C.6: Nik's Overall Plural Error Type Frequencies.....	158
Figure C.7: Gia's Overall Determiner Error Type Frequencies.....	158
Figure C.8: Nik's Overall Determiner Error Type Frequencies.....	159
Figure D.1: A cow is eating grass.....	160
Figure D.2: Three sheep are running.....	160
Figure D.3: A polar bear is washing a cup.....	161
Figure D.4: A chicken is jumping on a trampoline.....	161
Figure D.5: Two monkeys are opening a window.....	162
Figure D.6: Three cows are drinking water.....	162
Figure D.7: A sheep is walking.....	163
Figure D.8: Two bears are drying cups.....	163
Figure D.9: Two chickens are dancing.....	164
Figure D.10: A monkey is opening a door.....	164
Figure E.1: Woman shopping.....	165
Figure E.2: Men with vegetables.....	165
Figure E.3: Child's birthday party.....	166

<i>Figure E.4: Carnival.....</i>	<i>166</i>
<i>Figure E.5: Zoo.....</i>	<i>167</i>
<i>Figure E.6: Classroom.....</i>	<i>167</i>

# Chapter 1: Introduction

## 1.1 Purpose

The purpose of this study was to investigate the effects of bimodal bilingualism on English morphological development in two populations: hearing children with Deaf<sup>1</sup> parents (kids of Deaf adults, or kodas) and Deaf children who receive cochlear implants (CIs) and have Deaf parents. As can be seen from the nature of these populations, bimodal bilingualism is the knowledge of two languages in two modalities, oral/aural and manual/visual. These bimodal bilingual children learn American Sign Language (ASL) from their Deaf, signing parents (and other signing family members) and English from hearing family members and the wider community. Verbal affixes (3<sup>rd</sup> person plural *-s*, past tense *-ed* and irregular past tense), plural (*-s* and irregular plural) and articles (indefinite *a(n)*, definite *the*) were the morphemes included in this study.

There are practical as well as theoretical reasons for carrying out this research. The primary practical purpose of this study was to provide data that can help distinguish normal bilingual language acquisition from impaired development that might require clinical intervention. Bilinguals in general are at risk of being misidentified as language impaired (Thordardottir, 2014; Paradis, 2006; Morgan et al., 2013), and this research adds to the growing literature that attempts to establish expectations for language development in unimpaired bilinguals. This issue is especially fraught for children with CIs, who have been shown to

---

<sup>1</sup>The term Deaf is used to refer to people who use ASL and identify as belonging to their own culture and community, while deaf is used to refer to audiological status.

struggle acquiring even one single spoken language after implantation (e.g., Geers, Moog, Biedenstein, Brenner & Hayes, 2009; Duchesne, Sutton & Bergeron, 2009; Ertmer, Kloiber, Jung, Kirleis, & Bradford, 2012; Nikolopoulos, Dyar, Archbold & O'Donoghue, 2004). Bimodal bilinguals are an important population for study given the history of sign language suppression (Baynton, 1998) and the fairly recent establishment of sign languages as full, natural languages following the work of authors such as Klima & Bellugi (1979). Furthermore, for children with CIs, the role of sign language input as help or hindrance to spoken language development is controversial (see Davidson, Lillo-Martin & Chen Pichler, 2014 for a review).

This study also contributes to the discussion of theoretical issues, such as the role of input in language development, neuroplasticity in language acquisition, and the interaction of bilinguals' languages. To the first point, bilingualism is a crucial test for theories of the role of input because, within an otherwise normal environment (i.e., no confounding factors such as abuse or neglect), a bilingual child may receive a drastically lower amount of input in each of their languages than a monolingual child. For example, a prototypical bilingual child receives half of their input in each language, meaning that in each language, they receive half of the input of a typical monolingual child. By considering how language acquisition proceeds in the context of half the typical input, questions about the relationship between input and development can be addressed.

Moreover, bimodal bilingual children with CIs also experience a delay in exposure to their spoken language, the duration of which depends on the timing of the implantation surgery. This delay affects not only the total amount of spoken language input a child with a CI will receive, but also the age at which exposure to spoken language begins. The initial lack of auditory input could be detrimental to spoken language outcomes if auditory stimulation does not

begin within the sensitive period for cortical development within the auditory pathways (e.g., Sharma, Nash & Dorman, 2009). Conversely, early exposure to a natural sign language might improve subsequent spoken language outcomes if there are similar sensitive periods for cortical development of language regions of the brain that are not modality dependent. While neuroplasticity within the auditory cortex is not an issue that is pertinent only to bimodal bilingual children with CIs, early access to a full, natural sign language makes this a population uniquely relevant to questions about neuroplasticity within general language regions of the brain. Although this study cannot provide direct measures of cortical development, successful spoken language outcomes are inextricably connected to it.

Lastly, although it is widely agreed that bilinguals do not have a single, fused language system (Serratrice 2013), much recent research has focused on the ways in which a bilinguals' languages can influence each other (e.g., Yip & Matthews, 2007; Döpke, 1998). The typological distinctiveness of ASL and English, as well as the fact that they are produced in two different modalities, makes this an interesting language pair to consider (see Section 2.2 for more discussion).

## **1.2 Why Study Morphological Development?**

Morphological development is a particularly important aspect of language acquisition because it is often considered the core deficit (e.g., Leonard, 1989; Rice, Wexler & Cleave, 1995; Gopnik & Crago, 1991) in one of the most common language disorders affecting monolingual children: Specific Language Impairment (SLI), also referred to as Developmental Language Disorder (DLD). This language deficit occurs without obvious causes such as

intellectual disability or hearing impairment, although some authors have found high co-morbidity rates with other deficits like Developmental Coordination Disorder (Hill, 1998) and Attention Deficit Hyperactivity Disorder (Redmond, 2005). Because, as mentioned above, bilingual children are at risk of being mistakenly identified as language disordered, it is particularly important to consider typical bilingual morphological development. The course of language development in bilingual children is often somewhat different from that seen in monolingual children and it can be difficult to distinguish delayed, but otherwise typical development from true language impairment. A number of authors have already made progress in this area, and their work will be discussed in sections 1.4 and 2.1.3 below.

### **1.3 Organization of Dissertation**

As mentioned above, this study looked at bimodal bilingual hearing and Deaf children with cochlear implants. The data come from two main sources: longitudinal videos of spontaneous play sessions and elicited speech samples. Morphological accuracy was coded based on presence/absence of morphemes in obligatory contexts in both types of language samples. The data from these analyses will constitute the novel empirical contribution of this dissertation.

The remainder of this chapter discusses some questions of what it means to be bilingual, general language development in bilinguals, the basics of cochlear implants and previous research on general language development in children with cochlear implants. Chapter 2 reviews previous research in morphological development in monolingual and bilingual children in the introduction, and the rest of the chapter is devoted to presenting results from the present longitudinal study of hearing bimodal bilinguals. Chapter 3 discusses the longitudinal data from

the Deaf bimodal bilinguals with CIs after introducing results on morphological development in monolingual children with CIs. Chapter 4 considers the results from the elicitation study that includes data from both groups of bimodal bilinguals at slightly older ages. Chapter 5 provides conclusions based on the discussions in the previous three chapters.

## **1.4 Bilingualism**

### **1.4.1 What is Bilingualism?**

While the term bilingual generally refers to people who speak two languages, in reality the bilingual experience varies on so many dimensions that it is difficult to characterize the typical bilingual. For example, some people are born into families in which the parents speak two different languages and use both with their children. These children are exposed to both languages from birth and can clearly be referred to as simultaneous bilinguals because they acquire both languages at the same time. On the other end of the spectrum, other bilinguals study a second language in college, travel abroad and become fluent. These individuals can be referred to as sequential bilinguals (or second language learners) because they fully acquire one language before their first exposure to the second.

In between these two extremes are those who begin learning a second language in early childhood, perhaps at the start of school or upon moving to a new country. Authors disagree about when a bilingual should be considered sequential versus simultaneous with some authors requiring exposure to both languages by one month from birth for the simultaneous label (e.g. De Houwer, 1995) and others allowing for exposure to the second language as late as four years (e.g., Genesee & Nicoladis, 2007). Sometimes, children who receive input in their second



language beginning within the first few years of life are referred to as early successive bilinguals (Unsworth, 2013). While this may seem pedantic, language outcomes are likely to differ between individuals exposed at different ages due to the influences of factors such as brain plasticity and total amount of language exposure. Because this dissertation is concerned with childhood bilingualism, research on second language acquisition will not be reviewed here, but work that includes simultaneous or early successive bilinguals will be included.

Another important factor is the amount of input an individual receives in each language. The prototypical bilingual would receive half of their input in each language, meaning that they are exposed to roughly half of the amount of input in each language as a monolingual would be. Yet many bilinguals do not receive equal input in each language, making this issue more complex. The idea of a threshold has been proposed, according to which a bilingual must receive at least  $x$  amount of input to achieve monolingual-like outcomes. For example, Thordardottir (2011) found that a bilingual child must receive 50% of their input in one language to have a receptive vocabulary comparable to monolinguals in that language, while  $>60\%$  input was required for expressive vocabulary. Interestingly, Unsworth (2015) found that a bilingual child can receive as little as 35% input within one language and still be as proficient on a measure of grammatical development (mean length of utterance or MLU) in this language as in his other language (i.e., the one that makes up 65% of his language input). However, while Unsworth used an MLU differential to assess language dominance in bilinguals, she did not directly compare performance with monolinguals to determine at what point the two groups become indistinguishable.

While numerous other factors can affect bilingual outcomes (e.g., number of conversational partners in each language, relative prestige of the languages, or amount of output

a bilingual produces in each language (see Unsworth, 2013; 2015b for discussion), limited data is available on these issues for our subjects. In respect to age of exposure, hearing bimodal bilinguals are generally considered simultaneous bilinguals. They are exposed to spoken language from hearing family members and sign language from Deaf and hearing family members from birth. Deaf parents will also often use spoken language to some extent with their hearing children (van den Bogaerde & Baker, 2005; Pizer, 2008), but this phenomenon is not well understood. The deaf bimodal bilinguals with CIs are exposed to sign language from birth and only begin learning spoken language after the implantation and activation of their CIs. All of the children in this study were implanted after the age of 16 months, and before three years of age, so they would not meet a strict definition of simultaneous bilingualism, but could instead be considered early successive bilinguals.

Both groups of bimodal bilinguals are relatively balanced in amount of input in each language, but once school attendance begins, English input likely increases. In addition, the children with cochlear implants attended speech therapy sessions for their English. In America, ASL is a minority language, which has historically been considered low prestige, or even denied acknowledgment as a language (Baynton, 1998). Future research on these populations should include more precise measures of input quantity, as well as collect data on other environmental factors known to affect language outcomes (see Sections 2.3.1 and 3.3.1 for more information about participants).

### 1.4.2 Language Development in Bilingual Children

In this section, a brief overview of the dense literature on language development in simultaneous/early successive bilinguals will be given. Results are divided into the basic language areas of phonology, vocabulary, and syntax, with a discussion of morphological development reserved for the following chapter. Much of this research has been biased in that performance outcomes are presented only for the majority language, often for the practical reason that norms or assessments were not available for the minority language(s) under study. As is generally the case with monolingual children, bilinguals often perform better on receptive than expressive measures of language.

In most areas of language development, research has found quantitative, not qualitative differences between monolinguals and bilinguals. For example, while a bilingual child may have a smaller vocabulary in one of their languages when compared to monolinguals, their first words will appear within the same age range expected of monolinguals (Pearson, 2013). Similarly, although a bilingual child may score lower on a test of grammar in one of their languages, they will begin combining words at the same age as monolinguals (*ibid*). Furthermore, many of these quantitative differences disappear when development in both languages is considered (*ibid*).

While some authors discuss a grace period for bilinguals during which they can catch up to their monolingual peers (e.g., Paradis 2010), this issue is too complex for a simple answer. Paradis (2010) stresses that standardized tests need to be normed on bilinguals as well as monolinguals in order to truly be useful for diagnosing language disorders in this population. Furthermore, she insists that norming data from bilinguals be organized based on length of time and amount of exposure to the target language so that an appropriate comparison group can be chosen. Thordardottir (2014) takes a somewhat simpler approach, saying that bilingual children

rarely score below monolinguals in both of their languages, and so those children who do likely have a language impairment. Both of these approaches are problematic for bilinguals exposed to under-studied minority languages with no well-developed standardized tests. For additional helpful reviews of bilingual language development see Serratrice (2013) and Unsworth (2013).

### ***Phonology***

Even at the youngest ages, bilingual children can distinguish between the sounds of their two languages. For example, newborns not only show a preference for the languages spoken by their mother, they can discriminate the two at birth (Byers-Heinlein, Burns, & Werker, 2010). By six months of age, bilinguals are generally on par with monolinguals in discriminating phonetic contrasts that are phonemic in either of their languages (e.g., Sundara, Polka and Molnar, 2008). Bilinguals acquire two phonological inventories in the same time frame as monolinguals, but there is interaction between the languages (Fabiano-Smith & Barlow 2010) and they are sometimes less accurate in each language than monolinguals (Fabiano-Smith & Goldstein 2010).

Despite all of this, phonology seems to be an area of language that is especially sensitive to age of acquisition effects. For instance, Huang (2013) found that speech production was more strongly related to age of acquisition than performance on a grammaticality judgment task. On the other hand, for simultaneous/early successive bilinguals, phonological production can be an area of relative strength when compared to vocabulary and grammar (Hoff & Core, 2015).

### ***Vocabulary***

Depending on the language pair, bilinguals may need to pay attention to more phonetic detail than monolinguals. This is because while a phonetic contrast is not phonemic in one language, it

might be in another. For example, dental vs. alveolar /n/ is a phonemic contrast in Tamil but not English (Serratrice, 2013). This could affect word learning if a Tamil-English bilingual child considers the contrast phonemic in English at any point, because they are likely to hear both variants in their English input (*ibid*). Evidence that this issue interferes with word learning comes from studies such as Fennel, Byers-Heinlein & Werker (2007) in which bilinguals failed to learn nonce words differing only in place of articulation (/b-d/) until 20 months of age, while monolinguals succeeded at only 17 months.

Another possible impediment to word learning in a bilingual context is the mutual exclusivity bias, which monolinguals have been shown to use in numerous studies (e.g., Markman, Wasow & Hansen, 2003). According to this hypothesis, children assume a new label refers to an unknown object rather than one for which they already have a label. Yet bilinguals need to learn two words to refer to the same object in each of their languages and therefore cannot assume that a new word refers to an object they don't have a label for. Evidence shows that bilinguals overcome this difficulty quickly: their early vocabulary contains translation equivalents, or words with the same meaning in both of their languages (e.g., Pearson, Fernández and Oller, 1995). Yet experimental studies have also shown that bilinguals do not match new labels to unknown objects, unlike monolinguals (Houston-Price, Caloghiris and Raviglione 2010).

Finally, while bilinguals may have a smaller vocabulary than monolinguals in each language individually, when both languages are considered, they know a similar (or larger) number of words for different concepts (e.g., Pearson, Fernández and Oller, 1995). Therefore, total conceptual vocabulary is often used as a more accurate measure of vocabulary development in bilingual children. Nevertheless, scores in at least one language are typically in the normal range on standardized tests, albeit lower than monolingual comparison groups (Bialystok, Luk, Peets &

Yang, 2010). And as mentioned in Section 1.4.1 above, there might be an input threshold beyond which bilingual and monolingual vocabulary size is indistinguishable. For example, Thordardottir (2011) found that language input must at least reach 50% for receptive vocabulary to be comparable to monolinguals, while expressive vocabulary requires >60% input.

### *Syntax*

In monolingual children, vocabulary size is correlated with grammatical development (Dale, Dionne, Eley, and Plomin 2000; Dionne, Dale, Boivin and Plomin 2003). The same is found for bilinguals, but only within each language, not across the two (Marchman, Martínez-Sussmann, and Dale 2004). In other words, total conceptual vocabulary is not correlated with grammatical development. This suggests that if a child has a smaller vocabulary in one of their languages, their grammatical development in that language will be similarly reduced.

While evidence that bilinguals differentiate their two languages from birth is now widely accepted, many researchers have also found instances of interaction between the two grammars (e.g., Yip and Matthews, 2007; Serratrice, Sorace, and Paoli 2004; Paradis, Crago, and Genesee 2006). For instance, in Cantonese, wh-question words stay in-situ and do not move to sentence-initial position as in English (“you saw what?” vs “what did you see?”). Bilingual Cantonese-English children have been found to transfer this construction from their Cantonese into their English speech, producing questions without movement more often than English monolinguals (Yip and Matthews, 2007, Chapter 4). While this example happens to include utterances in only one language, many examples consider code-switches, or instances in which a speaker goes from one language to another within a sentence. Although many studies have demonstrated cross-

linguistic transfer, the exact conditions under which it occurs are disputed (e.g. MacSwan, 2000; Hulk & Müller, 2000; Cantone & Müller, 2005).

### ***Summary***

As the above discussion makes clear, bilinguals that receive sufficient input early enough can develop much as a typical monolingual does (at least in the majority language). Although bilingual children sometimes mix their two languages within and across sentences, this is not a sign of language confusion, but rather a grammatical option that is also available to competent adult bilinguals, although the exact rules governing this phenomenon are not fully understood. The following section will consider language development in hearing bimodal bilingual children.

### **1.4.3 Language Development in Bimodal Bilingual Children**

While there are many similarities between unimodal and bimodal bilinguals, learning two languages in different modalities provides at least two advantages for bilingualism researchers: (1) there is no possible confusion between the bilinguals' languages and (2) both languages can be produced at the same time. The first point is important because it affects not only the child's ability to distinguish between his two languages, but also the researchers'. For instance, in studies of vocabulary production, some early utterances cannot be categorized into one language or another because the phonological form is so primitive, the target could have been either of a bilingual's languages. No such ambiguity is possible in the study of bimodal bilinguals. And for those interested in language transfer, the possibility of producing a signed and a spoken word at the same time (i.e., code-blending) offers a more complete view of possible language interaction.

Many early studies of bimodal bilinguals were concerned only with how the spoken language was affected by aberrant or insufficient input from Deaf parents (Schiff, 1979; Murphy & Slorach, 1983) and did not consider these children as bilinguals. More recent studies acknowledge this fact and some even investigate the development of the sign language as well (e.g., Petitto, Katerlos, Levy, Gauna, Tétreault & Ferraro, 2001; Emmorey, Borinstein, Thompson & Gollan, 2008; Van den Bogaerde & Baker, 2005; Kanto, Huttunen & Laakso, 2013). Despite these advances, the work of assessing the sign language development of these bilinguals continues to be hindered by a lack of appropriate standardized tests and monolingual norms.

### ***Phonology***

Because the two languages of bimodal bilinguals use entirely separate articulators, unlike for unimodal bilinguals, there is no possibility of confusion between the two phonological inventories. Early researchers were concerned that the spoken language input provided by Deaf parents was unintelligible and did not provide a sufficient phonological model; in fact, it provided a deviant model that koda might copy in their speech (Schiff & Ventry, 1976; Murphy & Slorach, 1983). Schiff & Ventry (1976) used the Goldman-Fristoe Test of Articulation (GFTA) to evaluate phonological development in koda aged 6 months to twelve years old. They found that a large proportion (17% of their sample) had articulation and/or prosody problems. These children made errors such as substituting visually (on the lips) similar phonemes and using “deaf-like” articulation patterns, even when conversing with hearing adults.

More recent studies that have investigated phonological development in this group have found no delays relative to monolingual English speaking peers. Davidson, Lillo-Martin & Chen



Pichler (2014) found that kodas had standardized test scores at or above the monolingual mean on the Goldman-Fristoe Test of Articulation 2 (GFTA-2). Cruz, Kozak, Pizzio, Müller de Quadros & Chen Pichler (2014) used a pseudo-word/sign repetition task and observed similar accuracy rates between the bimodal bilinguals and the signing and speaking monolingual comparison groups.

Although it's not obvious exactly why contemporary research results conflict with early studies of the phonological development of bimodal bilinguals, it is clear that normal outcomes are possible even for children of Deaf parents. If a child's Deaf caregivers' speech is unintelligible, hearing family and community members would likely provide more useful spoken language input, while the parents could provide sign language models. It is possible that the modern context better acknowledges these two roles and provides more opportunities for kodas to interact with hearing individuals outside the family, leading to the normal phonological development found in recent studies.

### ***Vocabulary***

Similar to the literature on the phonological development of kodas, early research found that these children had smaller vocabularies than monolingual hearing children, while most modern research finds no differences. For example, Murphy & Slorach (1983) observed that kodas often used "thing" and "there," which they interpreted as evidence of a vocabulary deficit. Schiff & Ventry (1976) found that 19% of their participants presented with word finding and or comprehension problems during the administration of the Illinois Test of Psycholinguistic Abilities (ITPA) and the Peabody Picture Vocabulary Test (PPVT).

In contrast, Petitto, Katerelos, Levy, Gauna, Tétreault & Ferraro (2001) found that their French-LSQ (Quebec Sign Language) kodal's vocabulary size and growth rate in each language was well within the monolingual norms provided by the MacArthur-Bates Communicative Development Inventory (CDI). These children produced their first words and first fifty words at the same ages monolinguals are expected to do so (about 1;00<sup>2</sup> and 1;06, respectively). Brackenbury, Ryan & Messenheimer (2006) found that their English-ASL bimodal bilingual had an expressive vocabulary size similar to monolinguals at 16 and 20 months, despite receiving spoken language input only 20% of the time. Davidson et al. (2014) presented similarly impressive results for older kodal's on the Expressive Vocabulary Test (EVT). One recent study of kodal's exposed to spoken Finnish and Finnish Sign Language (Kanto, Huttunen & Laakso, 2013) found that only three of eight participants had vocabularies within the normal monolingual range, even when total conceptual vocabulary was considered. While the reasons for this discrepancy in results is unknown and needs further study, many kodal's can and do acquire vocabulary on a timescale similar to monolinguals, at least in the spoken/majority language.

### *Syntax*

There has been little research on the syntactic development of hearing bimodal bilinguals. Schiff (1979) found that very young kodal's used the correct word order of subject-verb-object and Jones & Quigley (1979) observed normal use of questions in both English and ASL up to age 5;05. On the other hand, Murphy & Slorach (1983) found up to 26% of utterances were syntactically deviant, meaning that they would never appear in the speech of a typical monolingual child. While it's not clear whether these deviant utterances could have been due to

---

<sup>2</sup> Age is given in the format (years; months) throughout this dissertation.

transfer of ASL syntactic constructions into English, Johnson, Watkins & Rice (1992) specifically observed such phenomena (i.e., transfer of subject pronoun copy) in their young koda. More recent research has focused on such instances of language transfer, finding evidence that bimodal bilinguals' English syntactic constructions differ from what is observed in monolinguals in areas like wh-question formation and argument omission (Lillo-Martin, Koulidobrova, Quadros & Chen Pichler, 2012; Koulidobrova, 2016).

### ***Summary***

Many of the earliest studies of hearing bimodal bilinguals found that their English phonology, vocabulary and syntax was qualitatively or quantitatively different from that of monolinguals, while more recent research has found remarkable similarities between the two groups. Numerous authors have found that aspects of ASL seem to influence the syntax of English sentences, but this phenomenon is observed in unimodal bilinguals as well.

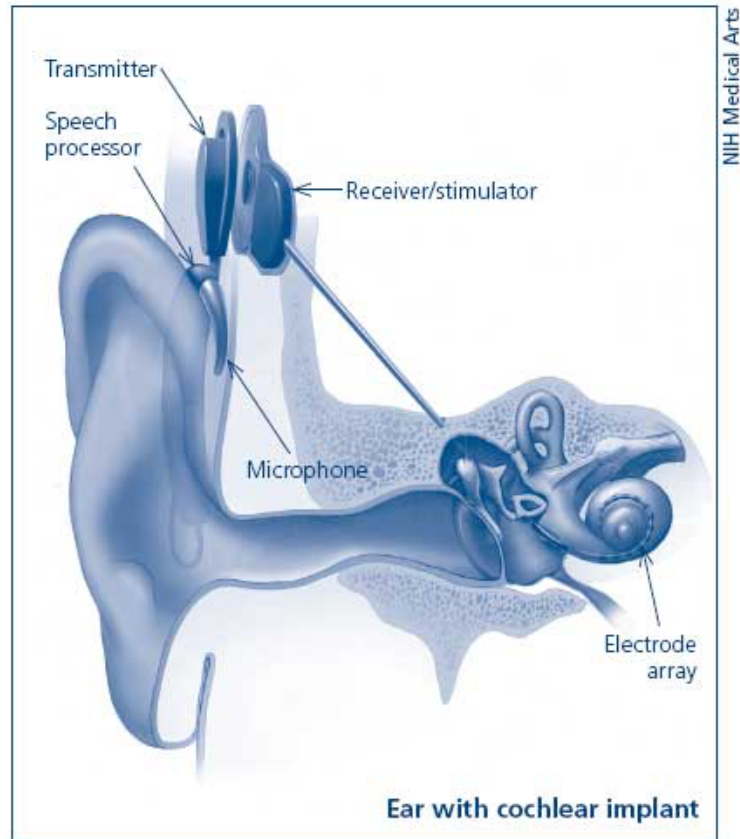
## **1.5 Children with Cochlear Implants**

### **1.5.1 What is a Cochlear Implant?**

A cochlear implant is a hearing prosthesis that replaces the function of the movement of the basilar membrane and hair cells within the cochlea with electrical stimulation. In normal hearing, the basilar membrane oscillates in response to sound waves transferred through the outer and middle ear. This oscillation causes inner hair cells to move and release a chemical that activates the auditory nerve (see e.g. May & Niparko, 2009 for a detailed explanation of acoustic hearing). Cochlear implants skip these steps and stimulate the auditory nerve electrically.

Although it cannot perfectly replicate acoustic (normal) hearing, a cochlear implant can transmit enough information to make spoken language acquisition possible. Here I will present a very brief overview of the parts and functions of a cochlear implant, pointing out critical differences from acoustic hearing that may be significant in language learning. For a more detailed overview see Wilson and Dorman (2009).

A cochlear implant consists of five main parts, all shown in Figure 1.1 below (Source: NIH/NIDCD, 2016). First, sound is picked up by the cochlear implant's microphone. It is then sent to the speech processor, which determines how the sound will be organized and transmitted in the cochlea. The signal then enters the transmitter, which transfers it across the scalp to the receiver/stimulator and converts it to electrical impulses. Finally, these electrical impulses are sent to the electrical array within the cochlea, which stimulates different regions of the auditory nerve. From this point on, the route of signal transfer used by the cochlear implant converges with that of normal acoustic hearing.



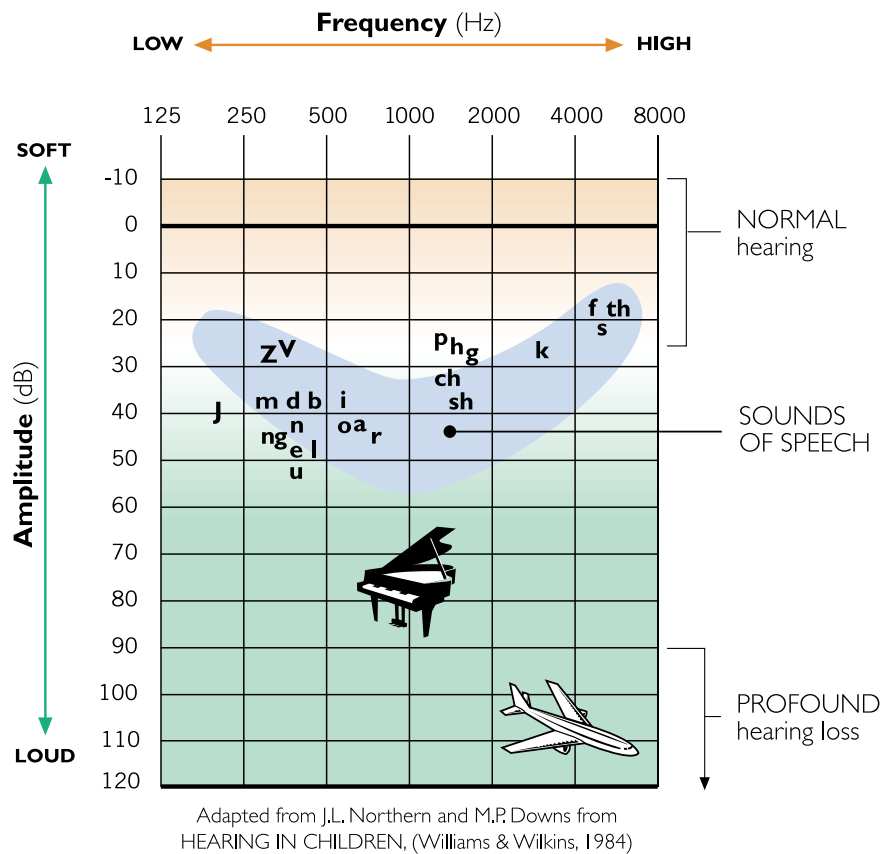
**Figure 1.1 Ear with Cochlear Implant (Source: NIH/NIDCD, 2016)**

While the cochlear implant attempts to utilize the same tonotopic (frequency to place) organization of acoustic hearing, there are a few important differences. First, the electrode array is not long enough to reach all of the way to the apex (innermost curve) region of the cochlea. Furthermore, ossification after meningitis infection or cochlear malformations may require partial insertion or use of shorter electrode arrays (e.g. Dodds, Tyszkiewicz & Ramsden, 1997). The apex region of the cochlea is sensitive to low frequency sounds, which are most important in conveying suprasegmental information, such as prosody. The lack of coverage in the apex means that the frequencies that are usually processed here will instead be sent to a different region of

the cochlea. Whether this actually is problematic likely depends on the amount of language experience an individual has before implantation and the flexibility of their auditory system.

The second possible issue is the limited number of electrodes present on the electrode array. Twelve to twenty-two electrodes are used convey sounds in the frequency range of about 250-6,000 Hz. This means that frequencies will be split into bands 261-479 Hz wide, much larger than the just noticeable difference of about 3 Hz found in psychoacoustic studies (e.g., Plack, 2005, chapter 5). This problem could be exacerbated by electrodes that must be deactivated due to malfunction, interference, etc. Ultimately this means that cochlear implant users will have poorer pitch discrimination, which could lead to confusion when two phonemes are similar in pitch, such as /f/ and /th/. Nevertheless, research has found that patients perform well on language tasks with as few as eight active electrodes (Wilson & Dorman, 2009).

Cochlear implant users also often have difficulty with speech comprehension in noise (e.g., Humphries et al., 2014). To deal with this issue, the sensitivity of the microphone can be adjusted, or the speech processor can be programmed to filter out sounds that are less likely to be part of the speech signal. This puts phonemes of lower amplitude (quieter) at risk of being filtered out. As can be seen in Figure 1.2 (Source: MED-EL, 2013), phonemes important for English present tense such as /s/ and /z/ are of relatively low amplitude and therefore fall into this category.



**Figure 1.2: Frequency Range and Amplitude of Speech Sounds (Source: MED-EL, 2013)**

### 1.5.2 Language Development in Children with Cochlear Implants

Much of the literature on language development in children with cochlear implants focuses on children born to hearing parents. This is possibly due to availability of subjects, because about 92% of deaf children are born to hearing adults (Mitchell & Karchmer 2004) and the Deaf community generally rejects cochlear implants, meaning that Deaf parents are less likely to have their children implanted (Mitchiner & Sass-Lehrer, 2011). Furthermore, when signed input is considered as a factor in language outcomes of children with CIs, the contrast is usually between

oral-only and total communication as the means of instruction (see Davidson et al., 2014 for a review). The signed input provided in total communication settings is different from the natural sign language input that children of Deaf adults receive. The aim of such communication methods (i.e., Total Communication, Simultaneous Communication, Signed English, etc.) is generally to represent the grammar of spoken English in the visual modality, and signed utterances generally conform to neither English nor ASL grammar (Marmor & Petitto, 1979).

Most of the studies of language outcomes in children with CIs show that, while language development after implantation is considerable, these children often lag behind their hearing, monolingual peers (e.g. Niparko et al. 2010; Nitttrouer et al., 2012). Some studies find that language development is commensurate with the duration of language exposure, meaning that children with CIs perform comparably to children matched with their hearing age (HA), or their age calculated from the activation of the implant, rather than chronological-age (CA) matched peers (Spencer & Guo, 2013; Caselli et al., 2013). Overall, wide variation in outcomes is observed, likely due to the many audiological and environmental factors that affect language development (see Section 1.5.3 for further discussion).

### ***Phonology***

Most studies on the phonological development of children with cochlear implants have found that they lag behind their chronological-age-matched peers on tests such as the GFTA or ALPHA-R Test of Phonology (Ertmer et al., 2012; Flipsen, 2011; Spencer & Guo, 2013). When performance was compared to hearing-age-matched peers, most children with CIs fell into the normal range (Flipsen, 2011) and this group difference even disappeared entirely if the children were given enough time to catch up (i.e., four years as in Spencer & Guo, 2013). Furthermore,



children with cochlear implants acquired consonants in a similar order as hearing children (Spencer & Guo 2013) and more accurately produced word-initial consonants, just as observed in hearing children (Ertmer et al., 2012).

As might be expected based on the limitations of lower frequency representation in cochlear implants, these children have been found to have difficulty with prosody and speaker discrimination. While Geers, Davidson, Uchanski & Nicholas (2013) found that identification of the emotional content of an utterances as well as discrimination between male and female voices was less accurate in children with CIs, they performed both tasks significantly above chance. Children with CIs are also less accurate in their own use of prosody to convey emotional content (Wang, Trehub, Volkova & van Lieshout, 2013).

### ***Vocabulary***

Vocabulary development is generally found to be a relative strength for children with cochlear implants when compared to morphological or syntactic development, even while many children continue to lag behind their chronological-age-matched peers (Duchesne, Sutton & Bergeron, 2009; Boons, De Raeye, Langereis & Peeraer, 2013; Geers, Moog, Biedenstein, Brenner & Hayes 2009, Spencer, 2004; Fagan & Pisoni, 2010). Moreover, expressive vocabulary is more likely to be impaired than receptive vocabulary (Yoshinaga-Itano, Baca & Sedey, 2010). Children with cochlear implants also perform worse on fast mapping, retention, and extension vocabulary tasks than would be expected for their chronological age, but similar to vocabulary-matched peers (Walker & McGregor, 2013).

## *Syntax*

Most studies assessing the syntactic development of children with cochlear implants have found this to be one of the most vulnerable areas of language (Tobey, Thal, Niparko, Eisenberg, Quittner & Wang, 2013; Boons et al., 2013; Geers et al., 2009; Young & Killen, 2002; Spencer, 2004). Most of these studies used standardized tests such as Clinical Evaluation of Language Fundamentals (CELF), Preschool Language Scale (PLS) or Test for Auditory Comprehension of Language (TACL). While these tests have given us a clear understanding that syntax is a vulnerable area for children, they unfortunately have not been able to elucidate exactly how the syntax of children with CIs differs from their hearing peers.

## *Summary*

There is wide variation in language outcomes for children with cochlear implants, the causes of which are still under intense scrutiny (see Section 1.5.3 below). While many children with CIs achieve language outcomes commensurate with their normal hearing peers, many do not. Comparisons based on the hearing experience of children with CIs are generally more favorable. Lower level language skills, such as basic phonology and receptive vocabulary, tend to be strengths, while syntax and prosody are weaknesses.

### **1.5.3 What Factors Affect Outcome?**

The factors that have been found to be predictive of language outcomes in children with cochlear implants can be divided into two main categories: child internal and child external. Most studies focus on the child external factors, such as age of implantation, perhaps because these factors might be changed through policy or education. The child internal factors that are

influential include pre-implant hearing level, with better hearing leading to better results (Barnard et al., 2015; Bouchard, Ouellet & Cohen, 2009). Children with higher IQs and/or better working memory as well as no additional disabilities are also more likely to have better language outcomes (Carter, Dillon & Pisoni, 2002; Dillon, Cleary, Pisoni & Carter, 2004; Geers, 2002; Edwards & Anderson, 2014; Boons et al., 2012), Later onset of deafness (post-lingual versus pre-lingual) leads to better outcomes (Dillon, Pisoni & Clearly & Carter, 2004; Spencer, 2004). Finally, girls tend to have better language outcomes than boys (Geers et al., 2009).

Child external factors can be further split into two main categories: audiological and environmental. Most studies find that age of implantation is crucial (e.g., Anderson et al., 2004), with some finding that implantation before 12 (Dettman, Pinder, Briggs, Dowell & Leigh 2007) or even 6 months (Colletti, Mandalà & Colletti, 2012) leads to better outcomes. When children are unilaterally implanted, the right ear is preferred, presumably because of the contralateral organization of the brain and the tendency for language to be lateralized to the left hemisphere (Henkin et al., 2008). Aspects of the cochlear implant itself are important, with insertion of electrode arrays with more electrodes spaced farther apart leading to better outcomes (Buchman et al., 2014). Full insertion of the electrode array is also beneficial, presumably for similar reasons, i.e., better frequency discrimination (*ibid*). Finally, bilateral implantation, or the use of a hearing aid in the un-implanted ear, aids in language acquisition (Caselli et al., 2012; Boons et al., 2012).

Environmental factors include characteristics of the family and educational placement. Children in families with higher SES, higher levels of parental education and fewer children perform best (Geers & Sedey, 2011; Geers, Brenner & Davidson, 2003; Geers et al., 2009; Szagun & Stumper, 2012). Children who are members of the majority race, specifically white in

America and Jewish in Israel, also have better outcomes than their minority peers (Barnard et al., 2015; Yehudai, Tzach, Most & Luntz, 2011). Although many early studies did not consider the role of parental language input, more recent studies have found that the quality of the input is important. Parental use of higher level facilitative language techniques, such as talking in parallel (discussing what the child is attending to), asking open-ended questions, and expanding the child's utterance to include missing morphemes have been found to predict better language outcomes (Cruz, Quittner, Marker & DesJardin, 2013; Szagun & Stumper, 2012; Szagun & Schramm, 2016).

Numerous studies have found that placement in oral educational settings (i.e., no sign) leads to better outcomes in spoken language (Archbold et al., 2000; Dillon, Pisoni, Cleary & Carter, 2004; Dillon, Burkholder, Cleary & Pisoni, 2004; Cullington et al, 2000; Geers, Nicholas & Sedey, 2003; Geer, Brenner & Davidson, 2003; Dunn et al., 2014; Boons et al., 2012). This conclusion is problematic because many children are placed in total communication settings after failing in oral-only educational settings. Very few studies have looked at children in true bilingual settings (e.g., Wiefferink et al., 2008).

Moreover, these studies are not valid arguments against the use of a full, natural sign language (such as ASL) with children with CIs because total communication is an unnatural language that fails to conform to the grammar of either the spoken or signed language (Marmor & Petitto, 1979). In fact, early language deprivation, such as that which a deaf child denied early sign language exposure experiences can have serious detrimental effects on language (for an overview see Mayberry, 2010 and Humphries et al., 2014) and cognition (e.g., number cognition as discussed in Spaepen, Coppola, Spelke, Carey & Goldin-Meadow, 2011).

### **1.5.4 Language Development in Unimodal Bilingual Children with Cochlear**

#### **Implants**

Many deaf children who receive cochlear implants are born into bilingual families, yet few researchers have addressed the issue of acquiring two or more spoken languages via electrical hearing. This issue is especially important because not all parents can speak the dominant language fluently, yet many are advised to not address their child in their native language for fear that it will inhibit the development of the majority language (McConkey Robbins et al., 2004; Waltzman et al., 2003). This can lead to less speech directed to the child overall, as well as input with fewer grammatical structures and more limited vocabulary. This well-intentioned advice can therefore inhibit language acquisition by depriving the child of good language models.

Of the handful of studies investigating bilingual language acquisition in this population, two found that bilinguals have worse outcomes than monolinguals (Deriaz et al., 2014; Teschendorf et al., 2011), four found no differences between monolinguals and bilinguals (Waltzman et al., 2003; McConkey Robbins et al. 2004; Thomas et al., 2008; Bunta & Douglas, 2013) and two did not directly address this issue (Guiberson, 2005; Yim, 2011). There are many factors that might account for the different outcomes in these studies. For example, the status of the non-dominant language in the broader society differs between the bilingual families in Germany (Teschendorf et al., 2011) and Switzerland (Deriaz et al., 2014), and the other studies conducted in America. Furthermore, some, but not all, of the studies that found no difference between monolinguals and bilinguals included families with proficiency in both languages, high

SES and children receiving therapy in both languages. More research is needed to better understand what characteristics are conducive to bilingualism in children with CIs and to guide clinical decisions in this population.

Three additional limitations of work in this area stand out. First, outcomes measures in the non-dominant language are sparse. This is understandable because tests have not yet been developed for many minority languages, but it is unfortunate because it provides an incomplete picture of bilingual children with CIs. Second, this bilingual population has not been followed longitudinally to see if any deficits are overcome with time and more language exposure, such as can be observed in the vocabulary development of typically developing, normal hearing bilinguals (Pearson, 2014). Finally, a limited range of standardized tests has been used, meaning that our knowledge of morpho-syntactic development can only be rudimentary. Despite these limitations, the next sections summarize the current findings in the areas of phonology, vocabulary and syntax.

### ***Phonology***

Tests used to assess receptive and expressive phonological development have included the Glendonald Auditory Screening Procedure (GASP), the Phonetically Balanced Kindergarten test (PBK), the Consonant-Vowel-Consonant test (CVC), the Multisyllabic Lexical Neighborhood Test (MLNT), the Common Phrases test, the Bamford-Kowal-Bench test (BKB), the Hearing-in-Noise test (all given in Waltzman et al., 2003) and the GFTA (Yim, 2011). Deriaz et al. (2014) and Teschendorf et al. (2011) administered phonology tests specific to French and German.

Waltzman et al. (2003) found no differences between the monolingual and bilingual groups on the numerous phonology tests they presented. Yim (2011) did not have a monolingual comparison group and did not calculate standard scores, so comparisons cannot be made with monolingual CIs or hearing monolinguals. She did find that amount of exposure to the second language (Spanish) was negatively correlated with English GFTA scores, while using the oral communication mode (rather than total communication) was positively correlated with GFTA scores. Deriaz et al. (2014) found that both monolingual and bilingual CIs performed well on their phonology tests, while Teschendorf et al. (2011) found that monolingual CIs performed better on these tests. Overall, bilingual CIs seem to perform similarly to monolinguals on tests of phonology.

### ***Vocabulary***

Vocabulary assessments have included CDI, the Peabody Picture Vocabulary Test (PPVT), Test de Vocabulario en Imagenes Peabody (TVIP), Expressive One Word Picture Vocabulary Test (EOWPVT), as well as German and French tests of expressive and receptive vocabulary. Deriaz et al. (2014) and Teschendorf et al. (2011) found that monolinguals outperformed bilinguals on vocabulary tests, while Thomas et al. (2008) found that bilinguals tended to score better on tests of vocabulary. Again, Yim (2011) did not provide standard scores or have a comparison group, but scores increased with age and duration of implant use. More research is needed to determine whether vocabulary development in bilingual children with CIs follows a similar pattern to hearing bilingual children, as discussed in Section 1.4.2.

### ***Syntax***

Standardized tests of language such as the PLS, the Reynell Developmental Language Scales (RDLs), the Oral and Written Language Scales (OWLS) and a French language test called the Evaluation du Langage Oral (ELO) were the only tests that included morpho-syntax. Deriaz et al. (2014) found that bilinguals performed worse than monolinguals on the ELO, while Waltzman et al. (2003), McConkey Robbins et al. (2004) Thomas et al. (2008), and Bunta and Douglas (2013) found that both groups performed similarly on the PLS, RDLs or OWLS. While these results are encouraging for the overall language development of bilingual children with CIs, more targeted tests are needed to address specific questions about syntactic development.

### **1.5.5 Language Development in Bimodal Bilingual Children with Cochlear**

#### **Implants**

Research on true bimodal bilingual children with cochlear implants has only just begun. Davidson et al. (2014) found that Deaf bimodal bilingual children with Deaf parents exposed to ASL from birth perform as expected for hearing children of the same chronological age on standardized tests of phonology (GFTA), vocabulary (EVT) and syntax (PLS). Hassanzadeh (2012) found that Persian Deaf bimodal bilingual children with CIs outperformed monolingual children with CIs. Both of these studies used standardized language tests, which are good at assessing overall language development but often miss more fine-grained patterns of deficit. For example, Davidson et al. (2014) used standardized tests that did not specifically target morphology, and it is possible to score within the normal range even if children have significant problems with morphology. The remainder of this dissertation will attempt to address such issues



with the study of morphological development in the spontaneous and elicited speech of hearing and Deaf bimodal bilinguals.

## **Chapter 2: Morphological Development in Hearing Bimodal Bilingual Children's Spontaneous Speech**

In this chapter, I discuss the morphological development of hearing bimodal bilingual children in longitudinal spontaneous speech samples. In order to set the stage for comparing performance of bimodal bilingual children with hearing monolinguals, the chapter begins with a brief review of the literature on morphological development in hearing monolingual children in Sections 2.1.1 and 2.1.2. Next, a review of morphological development in unimodal and bimodal bilingual children is provided to help anticipate our results and elucidate what factors could be driving any differences between our sample and monolingual children in Sections 2.1.3 and 2.1.4. In Section 2.2, predictions are made for the hearing bimodal bilinguals based on the literature review. Section 2.3 describes the participants and methodology while Section 2.4 and 2.5 present and discuss the results.

### **2.1 Background**

#### **2.1.1 Monolingual Morphological Development**

One of the most influential works on monolingual English-speaking children's morphological development was Brown's (1973) study of spontaneous speech samples from Adam (2;03-3;06), Eve (1;06-2;03) and Sarah (2;03-4;00). Brown found that his subjects first began to use morphemes, such as those that indicate tense or aspect, when their mean length of utterance (MLU) ranged from 2.0-2.5, and that these children did not reach mastery (>90% accuracy) on many morphemes even by the time their MLU reached 4.0. Additionally, the age at

which children began producing utterances that averaged four morphemes varied substantially, even in this small sample of three children. Adam, Sarah and Eve reached this MLU stage at 3;06, 4;00, and 2;03, respectively.

Despite this variation, Brown found that, for the 14 specific morphemes he focused on, order of acquisition was remarkably similar across children. Similar orderings have also been found by other researchers (de Villiers & de Villiers, 1973). Lahey, Liebergott, Chesnick, Menyuk and Adams (1992) used a larger sample of 42 children (compared to Brown's three and the deVilliers' twenty-one) to investigate variability in grammatical morpheme use. As can be seen in Table 2.1, which shows the rank order of acquisition of these 14 morphemes found across the three studies,<sup>3</sup> there is some variability in order of acquisition. Gray scale has been used to highlight (possibly) significant differences in order of acquisition.

The age at which children master these morphemes also can vary quite substantially. Table 2.2 shows the ages (in months) at which Lahey et al.'s participants and the approximate ages Brown's Adam, Eve and Sarah reached criterion for these 14 morphemes<sup>4</sup>. It is important to note that in Lahey et al.'s (1992) study, a wide range of performance was found within each age group. Although this range was most narrow in the oldest age group (35 months), variation up to 86% was still found (e.g. for the contractible auxiliary).

---

<sup>3</sup> The Lahey et al. (1992) data is based on their ranking by MLU level, not age, which seems to be closest to the methodology used by Brown (1973) and de Villiers and de Villiers (1973). This means that data was organized into MLU ranges such as 2.50-2.99, 3.00-3.49, et cetera, and the morphemes that reached the criterion considered for acquisition (group mean of 80% in two transcripts) earlier are ranked earlier.

<sup>4</sup> Based on Lahey et al.'s (1992) Table 3 and Brown's (1973) Figure 14. Lahey et al. split their participants into three age groups (25, 29, and 35 months).

**Table 2.1 Order of Acquisition of Brown's 14 Morphemes**

<b>Morpheme</b>	<b>Brown (1973)</b>	<b>de Villiers &amp; de Villiers (1973)</b>	<b>Lahey et al. (1992)</b>
progressive <i>-ing</i>	1	2	3
on	2.5	2	N/A
in	2.5	4	N/A
plural	4	2	1
irregular past	5	5	9.5
possessive <i>-s</i>	6	7	9.5
uncontractible copula	7	12	5.5
articles <i>a(n)/the</i>	8	6	N/A
regular past <i>-ed</i>	9	10.5	5.5
regular 3rd person <i>-s</i>	10	10.5	5.5
irregular 3rd person	11	8.5	5.5
uncontractible auxiliary	12	14	9.5
contractible copula	13	8.5	2
contractible auxiliary	14	13	9.5

Brown (1973) and de Villiers and de Villiers (1973) also tried to determine what factors influence the order of morpheme acquisition. They found that syntactic and cognitive complexity of morphological constructions were important. Although Brown argued that parental input did not seem to be a factor, much recent research has taken a usage-based approach arguing to the contrary (e.g., Lieven, Behrens, Speares & Tomasello, 2003; Pine, Conti-Ramsden, Joseph, Lieven & Serratrice, 2008, Pine & Lieven, 1997; Theakston, Lieven, & Tomasello, 2003; Theakston & Rowland, 2009).

**Table 2.2 Age of Acquisition of Brown's 14 Grammatical Morphemes**

<b>Morpheme</b>	<b>Lahey et al.</b>	<b>Adam</b>	<b>Sarah</b>	<b>Eve</b>
<b>progressive - <i>ing</i></b>	35	30	34	21
<b>on</b>	N/A	30	34	21
<b>in</b>	N/A	30	34	23
<b>plural</b>	29	30	34	23
<b>irregular past</b>	35	35	34	did not reach criterion
<b>possessive -s</b>	did not reach criterion	38	37	23
<b>uncontractible copula</b>	35	35	37	did not reach criterion
<b>articles <i>a(n)/the</i></b>	N/A	38	37	did not reach criterion
<b>regular past - <i>ed</i></b>	did not reach criterion	did not reach criterion	did not reach criterion	26
<b>regular 3rd person -s</b>	35	did not reach criterion	44	did not reach criterion
<b>irregular 3rd person</b>	35	38	did not reach criterion	did not reach criterion
<b>uncontractible auxiliary</b>	35	did not reach criterion	did not reach criterion	did not reach criterion
<b>contractible copula</b>	35	did not reach criterion	did not reach criterion	did not reach criterion
<b>contractible auxiliary</b>	did not reach criterion	did not reach criterion	did not reach criterion	did not reach criterion

Extending beyond English, other researchers have found that children learning a variety of languages go through an optional infinitive (OI) stage, in which verbs are often unmarked for tense (e.g., Wexler, 1990, 1994, 1998; Hoekstra & Hyams, 1998). While in English the infinitive is homophonous with a bare stem, the infinitive form is distinct in many languages, allowing researchers to determine that the non-tensed form used most often is infinitive. Researchers have not agreed on a clear syntactic pattern that can account for these omissions, although Hoekstra and Hyams (1998) propose a semantic account. Whether English-speaking children's omission of verbal morphology is comparable to infinitive forms in other languages is still unclear. However, there are common patterns. For example, for children in this OI stage, when tense morphemes are produced, they are used correctly. Using both experimental methods and data from spontaneous speech, Rice, Wexler and Hershberger (1998) found that English-speaking children begin using tense morphemes reliably by about age four.

It is widely agreed that when English-speaking children make errors, they are typically errors of omission, in which the morpheme is not produced at all, or errors of over-regularization, in which an irregular verb or noun takes a regular ending such as past *-ed* or plural *-s*. Additionally, some claim that the frequency of over-regularization follows an upside down U-shaped pattern, with few errors at the earliest stages of morphological acquisition, followed by increasing error frequency, which then returns back to a low rate in the later stages of morphological acquisition (see Marcus, Pinker, Ullman, Hollander, Rosen & Xu, 1992 for a thorough review of and argument against this theory). The U-shape of over-regularization is thought to be due to the child going through three stages: (1) rote memorization of past tense and plural markers (2) acquisition and over-application of the rules of past tense and plural

formulation and (3) memorization of exceptions to these rules (and possibly additional rule acquisition, as in the case of large groups of irregular verbs that follow the same pattern of past tense formation). Finally, errors of commission, or using a morpheme that should not be present, are exceedingly rare.

### **2.1.2 Specific Language Impairment (SLI)**

Because the language of children with SLI is plagued by morphological problems, it is useful to consider two theories of SLI here. The first theory considers SLI to be an extended optional infinitive (EOI) stage (Rice, Wexler & Cleave, 1995). This theory takes a maturational approach to language acquisition, in which language development is viewed as biological development, which occurs on a maturational timescale. Children with SLI undergo slower maturation (perhaps never fully maturing). This theory focuses on explaining deficits in the verbal domain; it cannot explain problems with morphemes like plural *-s* and the articles *a(n)/the*.

The second theory relies on the perceptual saliency of each morpheme and was proposed by Leonard (1989). This theory postulates that, all other factors being equal, morphemes that are more perceptually salient are more likely to be processed and learned by children with SLI. Leonard (1989) does not give a detailed hierarchy of perceptual salience in this paper, but gives a definition of “low phonetic substance morphemes” as “nonsyllabic consonant segments and unstressed syllables, characterized by shorter duration than adjacent morphemes, and, often, lower fundamental frequency and amplitude” (Leonard, 1989, pg. 186). According to Leonard, the following morphemes meet this definition, meaning that children with SLI will have

problems with them: regular plural *-s*, regular past *-ed*, possessive *'s*, 3<sup>rd</sup> person singular *-s*, articles *a(n)/the*, copula *be*, auxiliary *be*, modal *will*, infinitival *to* and complementizer *that*.

This is admittedly over simplified because the perceptual salience of these morphemes also depends on the environment in which they are produced. For instance, although both the phrase “*ducks swim*” and “*birds live*” contain the plural morpheme *-s*, it is more salient in the second phrase because it is not followed by a word that begins with the same phoneme [s]. Such detailed phonetic analyses are beyond the scope of this dissertation and so the following discussion considers the phonetic salience of these morphemes in isolation.

Table 2.3 outlines the expected order of acquisition of the morphemes studied in this dissertation according to the perceptual saliency approach (based partially on the discussion in Svirsky, Stallings, Ying, Lento & Leonard, 2002). Although still of low phonetic substance, the English articles, copula and auxiliaries are independent words and therefore expected to be relatively early acquired. Contracted copulas and auxiliaries are less salient, therefore they are separated into two categories: contractible and uncontractible. Contractible copulas and auxiliaries are more salient than 3<sup>rd</sup> person present *-s* and plural *-s*, because they sometimes appear in their uncontracted form. Progressive *-ing* is not an independent word, but contains a vowel and is syllabic, which leads to higher perceptual prominence. Plural *-s* is not syllabic, but is longer in duration than the past tense marker. It is also higher in pitch, which is particularly important for children with CIs because a cochlear implant conveys high pitches particularly well.

The syllabic allomorph *-es* was rarely observed in the data presented below, but one might expect it to be acquired earlier than its non-syllabic counterpart based on saliency. Finally, past *-ed* is non-syllabic and has a short duration. Again, the syllabic form of the regular past



tense was rarely observed, but may be expected to be acquired earlier than its non-syllabic counterparts.

**Table 2.3 Morphemes in Order from Most to Least Perceptually Salient**

<b>Morpheme</b>	<b>Acquisition</b>	<b>Notes</b>
a(n)/the; uncontractible copula & auxiliary	Earlier	full independent words
progressive <i>-ing</i>	↑	syllabic
contractible copula & auxiliary		longer duration and high frequency, sometimes uncontracted
3rd present & plural <i>-s</i> ;	↓	longer duration and high frequency
past <i>-ed</i>	Later	short duration, lower frequency

### 2.1.3 Bilingual Morphological Development

Unsworth (2013) summarizes the research in unimodal bilinguals and claims that, although the evidence is somewhat unclear, most studies find a quantitative, not qualitative difference between monolinguals and bilinguals in morphological development. For example, in a study of seventy four bilingual three-year-olds, Nicholls, Eadie & Reilly (2011) found that bilingual children produced a variety of English morphemes less accurately than the monolingual control group, but that both groups produced the same types of morphemes most and least accurately, suggesting a similar order of acquisition.

As with many areas of language development, researchers have found at least three important factors that affect bilinguals' performance on morphological tests: (1) transfer effects from one language to another, (2) amount of exposure to each language, and (3) age of exposure to the second language. The remainder of this section will discuss relevant studies in detail and relate findings to the population under study in this dissertation.

Nicoladis, Song & Marentette's (2012) study of English past tense morphemes demonstrates that there can be significant transfer effects between a bilingual's languages. These authors studied 5-12 year old sequential Mandarin Chinese-English and French-English bilinguals and found that overall accuracy rates between the two bilingual groups were similar, but lower than those expected for monolinguals ( $\approx 70\%$  vs  $>90\%$  accuracy). Although these two groups of bilinguals made a similar number of errors, more detailed analysis revealed an important difference. French-English bilinguals were more accurate with regular verbs (e.g. *kick-kicked*) while Chinese-English bilinguals performed better with irregular verbs (e.g. *run-ran*). This was interpreted as a transfer effect because French also uses a rule to form many past tense verbs, focusing these children on rule learning. Chinese has no such rule, perhaps leading the Chinese-English bilingual children to use a different strategy, such as rote-memorization. This would give them an advantage on irregular verbs, which must be memorized. ASL is somewhat like Chinese in that verbs do not change to mark tense, but there is a paradigm used to mark agreement with the subject and object for a number of verbs. The simple presence of such a system might similarly focus bimodal bilingual children's attention on rule learning, leading them to perform more like the French-English bilinguals in Nicoladis et al.'s (2012) study.

Interestingly, the Nicholls et al. (2011) study discussed earlier found that bilinguals exposed to a variety of different language pairs were more accurate with irregular plurals. This is because the bilingual group did not over-regularize nouns that undergo no change, like *sheep* and *deer*, while the monolinguals had learned the plural formation rule and often over-applied it to these irregular nouns. This result could indicate that, despite more accurate performance for irregular plurals, bilinguals were actually lagging behind in their acquisition of the regular plural morpheme.

A number of studies have investigated the role of the amount of input on morphological acquisition. Paradis, Nicoladis, Crago & Genesee (2011) used the Test of Early Grammatical Impairment (TEGI; Rice and Wexler 2001) to elicit English past tense morphemes from French-English bilinguals, half of which were simultaneous bilinguals. Language input was measured using a five-point scale in questionnaires that asked whether the parents spoke to the child in (1) only English, (2) mainly English, (3) French and English equally, (4) mainly French, or (5) only French. They found that, overall, the bilingual group did not perform as well as expected based on the monolingual norming data, but that this difference disappeared when only the bilinguals who received more input in the target language were compared to the monolinguals. Unfortunately, there were not enough subjects in the balanced input group (3) to consider their performance separately. Both groups of bilinguals were less accurate with the irregular past tense than the regular past tense verbs.

Elin Thordardottir (2014) used spontaneous speech samples to collect morphological development norms to aid in diagnosis of language disorders in bilingual populations. The large number of participants (139) were split into two age groups (three and five years old) and five language exposure groups: (1) monolingual English (2) more English (3) equal English and French (4) more French and (5) monolingual French. All of the children, excluding the two monolingual control groups, were exposed to both languages by the age of three. Thordardottir found that the balanced bilinguals, group (3), looked very similar in each language to the monolinguals in groups (1) and (5). Furthermore, groups (2) and (4) looked delayed in the language that they had less exposure to.

These results and those of Paradis et al. (2011) suggest that with the right amount of language exposure, bilingual children might be indistinguishable from monolinguals. As

discussed in the Method sections below, the hearing bimodal bilinguals in this study received about equal exposure to each language, which suggests that they should look like monolingual English speakers. However, the data from the bimodal bilinguals was collected over a span of several years, during which language exposure likely changed as the children began attending daycare or preschool. Limited data is available about changes in language exposure rates across time for this sample. Furthermore, French and English are typologically more similar than ASL and English, so it is not clear how well these results will generalize to the subjects in this dissertation.

Because the language experience of bimodal bilingual children with CIs can be similar in some ways to internationally adopted children, the study by Pierce, Genesee & Paradis (2013) on children adopted from China might be informative. They found that these children, who were adopted by age 1;01, acquired verbal morphemes in the same order as monolingual L1 learners of English and that they achieved mastery ( $\geq 90\%$  accuracy) by 47 months of age, or 34 months post-adoption. Based on length of exposure to English, these children are doing quite well, likely better than monolingual 3-year-olds. Pierce et al. suggest that this is because after adoption, these children are exposed to English only and in high SES families, which typically have better language outcomes. As with monolingual learners, these internationally adopted children also were more likely to make errors of omission than commission.

Research on second language (L2) English learners doesn't bode quite as well, as these children are often misdiagnosed as language disordered (Paradis, 2006), although this might be due to a protracted developmental trajectory rather than a permanent deficiency. Paradis (2006) found that children with a richly inflected first language or L1 (e.g., Spanish) more accurately produced English verbal morphology than those with an L1 that lacks verbal morphology (e.g.

Mandarin). Furthermore, both groups acquired morphemes in a different order than monolingual L1 English children. This suggests that early L2 language acquisition leads to qualitative as well as quantitative differences in morphological acquisition. However, as discussed in section 2.1.1, there is some variation in the order of morpheme acquisition even for monolingual English speakers.

#### **2.1.4 Bimodal Bilingual Morphological Development**

Few studies have focused on bimodal bilinguals. Schiff & Ventry (1976) found that five hearing children of deaf adults out of a sample of 52 showed some problems with morphology, such as morpheme omission and inaccurate verb tense, noun declensions or pronouns. Given the wide age range of their subjects (six months to twelve years) and the vague presentation of standardized test results, it is difficult to tell whether some of these errors were developmentally appropriate, given that even monolingual children omit morphemes at the earliest stages of development and commonly make errors with irregular verbs and nouns before learning the exceptions to the rules (e.g., Marcus et al., 1992). Monolinguals also make errors with noun declensions, especially during the OI stage, in which pronominal subjects often occur in the accusative case instead of the nominative case (e.g., Wexler, 1998).

Johnson, Watkins & Rice (1992) studied one hearing child of deaf adults who was exposed to ASL from birth and English after beginning daycare at the age of 2;03. This child acquired a number of English morphemes later than monolinguals when considering his chronological age, but early or on par with monolinguals when considering his age of exposure. Articles, plural and past tense morphology were acquired later than would be expected based on his age of exposure

to English. He also confused pronouns based on gender (he/she) more often than would be expected of a monolingual. This could be a transfer effect from ASL, which makes no gender distinction on pronouns.

Some more recent preliminary data on verbal morphology suggests that bimodal bilinguals might be more likely to make errors of commission (using incorrect person agreement or tense marking) than monolingual children (Koulidobrova, Lillo-Martin, Quadros & Chen Pichler, 2011). The explanation for such errors is unclear. Another study of English article acquisition found that bimodal bilinguals aged 2;00-3;00 omitted articles more frequently than the monolingual comparison (Quadros, Lillo-Martin, Koulidobrova & Chen Pichler, 2013). This was interpreted as an influence of ASL on English and was observed to a greater extent in bilinguals' code-blended speech to signing interlocutors, a phenomenon also observed by Petroj, Guerrero & Davidson (2014), Petroj (2015) and Davidson, Goodwin & Lillo-Martin (2013).

Why this type of transfer effect would occur requires some discussion of the nature of morphology in ASL. In many ways ASL is similar to Mandarin Chinese because it lacks concatenative tense morphology and often conveys tense through adverbs of time. A subset of ASL verbs is inflected for agreement, but these verbs agree not only with the subject as in English, but also with the object. Research on the acquisition of agreement in deaf ASL signers has found that it is acquired on a similar timescale to the English verbal morphemes and that when children make errors, they are errors of omission (Quadros & Lillo-Martin, 2007). Nouns can also be made plural by reduplicating a sign, but this is not obligatory. It is debated whether ASL possesses a definite article like English *the* (MacLaughlin, 1997; Koulidobrova, 2012), but if it does, it is not obligatory. Based on these properties of ASL, if there is transfer from ASL to

English it would likely lead to an increase in uninflected verbs and nouns, and more article omissions.

## **2.2 Predictions**

Based on the previous research on input in unimodal bilinguals, hearing bimodal bilinguals with equal exposure to ASL and English from birth should not differ from monolingual English peers in their morphological accuracy. On the other hand, the typological differences between ASL and English, more specifically the lack of obligatory tense and plural morphology, suggest that their performance might suffer because the absence of these morphemes in one of a bilingual's languages might hinder their development in the other (as with the acquisition of regular past tense in Chinese-English bilinguals discussed in Nicoladis et al., 2012). Because this part of the study is longitudinal in nature, and the language dominance of these children is likely to change over time as they enter preschool where they will receive more English input, it is possible deficits observable in early sessions will disappear as English exposure increases. Of course this type of change could also be due to a cumulative amount of English exposure rather than a shift in dominance. Unfortunately, our sample size was too small and homogenous to disentangle these two hypotheses.

If bilingual children go through an EOI stage, as Rice, Wexler, and Cleave (1995) hypothesize occurs in children with SLI, they might omit tense morphemes beyond the age at which monolingual peers do. As mentioned previously, this theory could not explain morphological errors outside of the verbal domain. Previous research has found errors of omission to be the most common error type in both monolinguals and bilinguals, although some

authors have found that bilinguals make more errors of commission than monolinguals and that they sometimes use *be* as an auxiliary to indicate tense rather than adding the tense morpheme to the verb itself (Pierce et al., 2013). It is predicted that hearing bimodal bilinguals' errors will mostly be errors of omission, but that they will possibly make more commission errors than monolinguals.

## **2.3 Method**

### **2.3.1 Participants**

Three male bimodal bilinguals aged 2;03-5;00, given the pseudonyms Ben, Lex, and Tom participated in this study. All three children had normal hearing and were born to at least one deaf, signing parent. They were exposed to both English and ASL from birth and were not diagnosed with any language disorders. They received about equal exposure to both languages, but likely became English dominant around the time they began attending (pre)school.

Table 2.4 provides information about the highest level of education completed by each participant's mother. This is provided as a measure of socio-economic status (SES) and is measured in years, with 12 being a high school diploma, 16 an undergraduate college degree and 16+ any amount of graduate school. It is important to note that all of these children are of high SES and that outcomes may be different for less advantaged hearing bimodal bilinguals, as is generally the case for monolinguals (e.g., Suskind et al., 2015). Table 2.5 shows the number of Deaf family members each child has as an indicator of amount of ASL exposure. All additional family members are hearing.



**Table 2.4: SES Information for Hearing Bimodal Bilinguals**

<b>Pseudonym</b>	<b>Status</b>	<b>Language Input</b>	<b>Mother's Education</b>
Ben	Hearing	English & ASL	16+
Lex	Hearing	English & ASL	16+
Tom	Hearing	English & ASL	16+

**Table 2.5: Deaf Family Members of Hearing Bimodal Bilinguals**

<b>Pseudonym</b>	<b>Mother</b>	<b>Father</b>	<b>Other Deaf Family</b>
<b>Ben</b>	Deaf	Deaf	Grandmother, Sibling
<b>Lex</b>	Deaf	Hearing	
<b>Tom</b>	Deaf	Deaf	

### 2.3.2 Data Collection

Language samples were collected as part of a larger study of bimodal bilinguals (Chen Pichler, Hochgesang, Lillo-Martin & Quadros, 2010; Quadros, Lillo-Martin & Chen Pichler, 2012; Chen Pichler, Lee & Lillo-Martin, 2014). This project was supported financially by the Gallaudet Research Institute and the National Institutes of Health (National Institute on Deafness and Other Communication Disorders), award number R01DC009263.

Children were recorded during spontaneous play with a researcher and/or parent for about an hour once a week over the course of several years. Sessions alternated between target English and target ASL. In target English sessions, children interacted with a hearing, but also bimodal bilingual, researcher or family member. In target ASL sessions, children usually interacted with a deaf researcher or family member, although on occasion a hearing, native signing researcher

interacted with the child in ASL. For this project, only target English sessions were analyzed because other researchers have found more blending and ASL-influenced structures in target-ASL sessions (Petroj et al., 2014; Lillo-Martin, Quadros, Chen Pichler & Fieldsteel, 2014; Davidson et al., 2013). All utterances that contained any spoken English were analyzed, which included some utterances in which the child also produced ASL signs. Morphological development was analyzed in sessions 3 months apart, with the exact age range depending on the available data, but generally spanning from age 2;00-5;00. Nineteen total samples were used, with at least five samples from each child, as shown in Table 2.6.

**Table 2.6: Hearing Bimodal Bilinguals' Spontaneous Speech Sample Information**

<b>Pseudonym</b>	<b>Status</b>	<b>Language Input</b>	<b>Age</b>	<b>Session #</b>	<b>Number of Utterances</b>
BEN	Hearing	Eng & ASL	2;03	1	100
BEN	Hearing	Eng & ASL	2;06	2	100
BEN	Hearing	Eng & ASL	2;09	3	100
BEN	Hearing	Eng & ASL	3;00	4	100
BEN	Hearing	Eng & ASL	3;03	5	100
BEN	Hearing	Eng & ASL	3;06	6	100
BEN	Hearing	Eng & ASL	3;11	7	100
BEN	Hearing	Eng & ASL	5;00	8	100
LEX	Hearing	Eng & ASL	3;00	1	100
LEX	Hearing	Eng & ASL	3;03	2	100
LEX	Hearing	Eng & ASL	3;05	3	100
LEX	Hearing	Eng & ASL	3;09	4	100
LEX	Hearing	Eng & ASL	5;00	5	100
TOM	Hearing	Eng & ASL	3;01	1	100
TOM	Hearing	Eng & ASL	3;03	2	100
TOM	Hearing	Eng & ASL	3;06	3	100
TOM	Hearing	Eng & ASL	3;10	4	100
TOM	Hearing	Eng & ASL	4;00	5	100
TOM	Hearing	Eng & ASL	4;11	6	100

### 2.3.3 Coding

The following aspects of morphology were coded for accuracy and error type in obligatory contexts (as determined by the native-English speaking researcher in the context of the videos):

- a. Verbal morphology – 3<sup>rd</sup> person present *-s*, regular and irregular past, copular *be*, auxiliary *be* and *do* and *have* (if present), progressive *-ing*. Distinctions were made between contractible and uncontractible copulas and auxiliaries.
  - b. Plural *-s* and irregular plural
  - c. Definite (*the*) and indefinite articles (*a*, *an*)
2. One hundred utterances of each of the longitudinal videos were analyzed. Interjections, imitations, repetitions and unclear utterances were excluded.
  3. A minimum of four obligatory contexts was required for data on each morpheme to be considered separately (based on Guo et al., 2013), but all instances of all morphemes contributed toward overall error rates and types.
  4. For all of the morphemes that have voiced/voiceless allomorphs, each allomorph was separately coded, but rarely did the number of each allomorph reach the lower limit of four obligatory contexts. This applies to morphemes such as those for 3<sup>rd</sup> person present *-s*, regular past tense and regular plural. While not strictly speaking allomorphs, all forms of copulas and auxiliaries were also collapsed together within their respective categories because of an insufficient number of uncontractible contexts (e.g., past tense, questions).
  5. Mean Length of Utterance (MLU) in words (MLU<sub>w</sub>) and morphemes (MLU<sub>m</sub>) was calculated for each longitudinal video on the basis of the 100 utterances analyzed.

Rules for calculating MLU were based on previously published literature. Detailed information can be found in Appendix A.

6. Seventeen sessions (89%) were also coded for modality. The modality of each word was coded as belonging to one of four categories: (1) Speech (2) Bimodal (3) Point and Speech and (4) Excluded. Utterances that were conveyed in speech only, with no signs present, were considered to be in the Speech modality. Utterances that contained any amount of speech and sign were considered bimodal. This included both code switches, in which the child began an utterance in one language and changed to the other at some point during the sentence, and code-blends, in which information was presented in both modalities simultaneously (see Emmorey, Borinstein, Thompson & Gollan, 2008 for a description of typical language mixing in adult ASL-English bilinguals.) The third category included spoken utterances produced along with an indexical point and no (other) signs. While pointing is a part of ASL grammar, it is also something that non-signing speakers use with their speech. Therefore, it is not obvious whether these utterances should be expected to look more like speech only or bimodal utterances. The last category included any utterances in which the speaker was not visible and modality was indeterminable. While sign only utterances were possible, they were not included in this study of English morpheme production.

### 2.3.4 Analyses

The target morphemes listed above were analyzed for overall accuracy as well as the types of errors made. A number of measures will be reported below. This section describes how each result was calculated.

1. Overall Verb Accuracy – This measure includes all errors with tense/agreement and aspect morphemes, regardless of whether there were at least four instances of each morpheme. Both regular and irregular past tense were included, although obligatory contexts for regular past tense morphemes rarely occurred. Accuracy was calculated by dividing the total number of correctly marked verbs by the total number of obligatory verbs.
2. Overall Plural Accuracy – This measure includes all errors with number marking, regardless of whether the target morpheme reached the four obligatory contexts or not. Both regular and irregular plurals were included, although nouns that required irregular plurals were rarely used. Accuracy was calculated by dividing the total number of correctly (un)marked nouns by the total number of nouns that could possibly have taken a plural marker (i.e., full nouns, excluding pronouns).
3. Overall Determiner Accuracy – This measure includes all types of errors with the indefinite and definite determiners. Accuracy was calculated by dividing the total number of correctly marked noun phrases by the total number of noun phrases that could possibly have taken a determiner (i.e., all full nouns, excluding pronouns). Note that errors of [n] omission in the indefinite determiner *a/an* alternation were not counted as errors for this study, but all subjects seemed to make these errors throughout the entire age range considered.

4. Overall Accuracy – This measure is an overall measure that includes the previous three measures.
5. Individual Morpheme Accuracy – For this measure, each morpheme discussed in section 2.3.3 was considered individually. At least four obligatory contexts were required for a morpheme to be considered. Errors of commission were not included in this category because only obligatory contexts were considered (not contexts in which a morpheme should not have been produced but was). Pragmatic errors for determiners were not included in order to better compare with results from monolingual children that did not include this error type.
6. Error Type Frequency - Errors were coded as one of the five different types listed below. Frequency was broken down into verb, plural and determiner as well as being calculated overall. Error frequency was calculated in the manner most appropriate to the error type, as described below.
  - a. Omission – Errors of this type were missing the target morpheme. Example: *She run* instead of *She runs*. Frequency was calculated by dividing the number of instances that should have had the morpheme but did not by the total number of instances in which the morpheme should have been present.
  - b. Commission – Errors of this type included a morpheme that should not have been added. Example: *I runs* instead of *I run*. Frequency was calculated by dividing the number of instances in which a morpheme was present but should not have been by the total number of instances in which a morpheme should not have been present.

- c. Over-regularization – Errors of this type only apply to irregular nouns and verbs. In these cases, a regular morpheme was over-generalized to an irregular noun or verb. Example: *She runned* instead of *She ran* or *persons* instead of *people*. Frequency was calculated by dividing the total number of irregular nouns or verbs that had a regular morpheme added by the total number of irregular nouns or verbs.
- d. Pragmatic – This type of error applies only to the determiners *a/the*. For example, *the* can only be used if a noun is specific and has been previously mentioned in the conversation (e.g., Brown 1973, pg. 264). Therefore, if a child used *the* when first mentioning the existence of something, this would have been coded as pragmatically incorrect. Frequency was calculated by dividing the total number of pragmatic errors by the total number of obligatory contexts for *a* and *the*.
- e. Other – All other error types, such as errors of verb choice, contraction of uncontractible verbs, etc. This could theoretically have been applied to all morphemes. Because of its amorphous nature, frequency was not calculated for this error type, but it was generally very rare.

### 2.3.5 Reliability

A second and third coder independently coded nine percent of the transcripts. This coding was then compared to the author's coding in order to obtain a measure of reliability. The overall agreement for verbs, determiners and plural markers is given in Table 2.7. Information about

differences in MLU results between the author's and reliability coders' calculations are given in Table 2.8.

**Table 2.7: Reliability Coding Results**

	<b>Percent Agreement</b>
<b>Verbs</b>	89%
<b>Determiners</b>	88%
<b>Plurals</b>	96%

**Table 2.8: Variability in MLU Calculations**

	<b>Mean Difference (SD)</b>	<b>Difference Range</b>
<b>MLU<sub>w</sub></b>	.19 (.16)	.09-.37
<b>MLU<sub>m</sub></b>	.3 (.19)	.13-.51

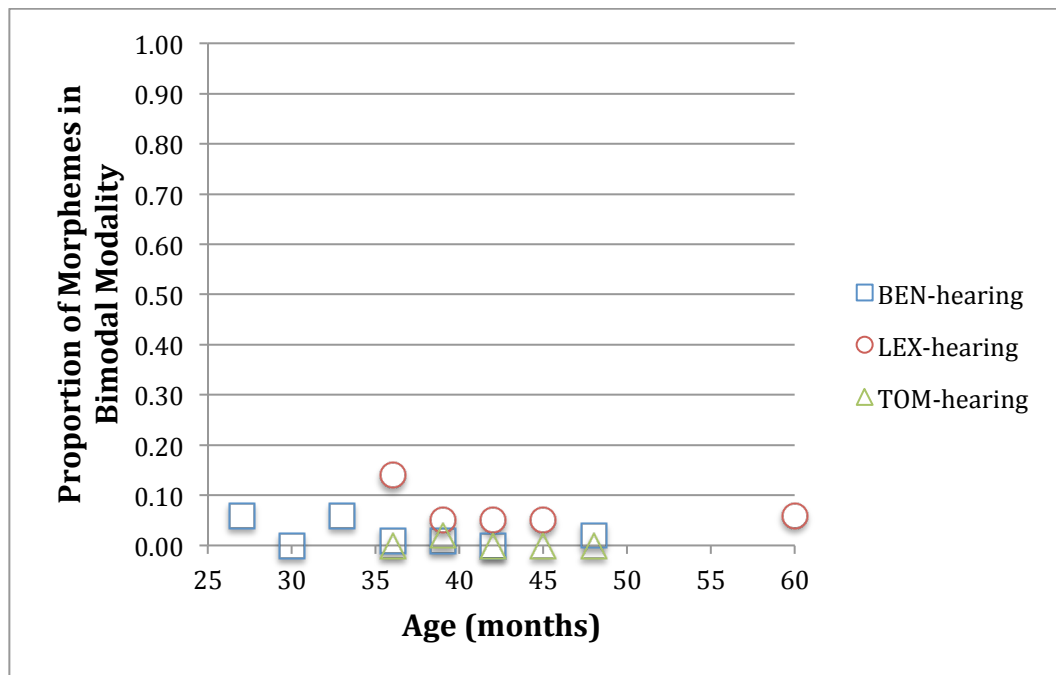
## 2.4 Results

### 2.4.1 Modality

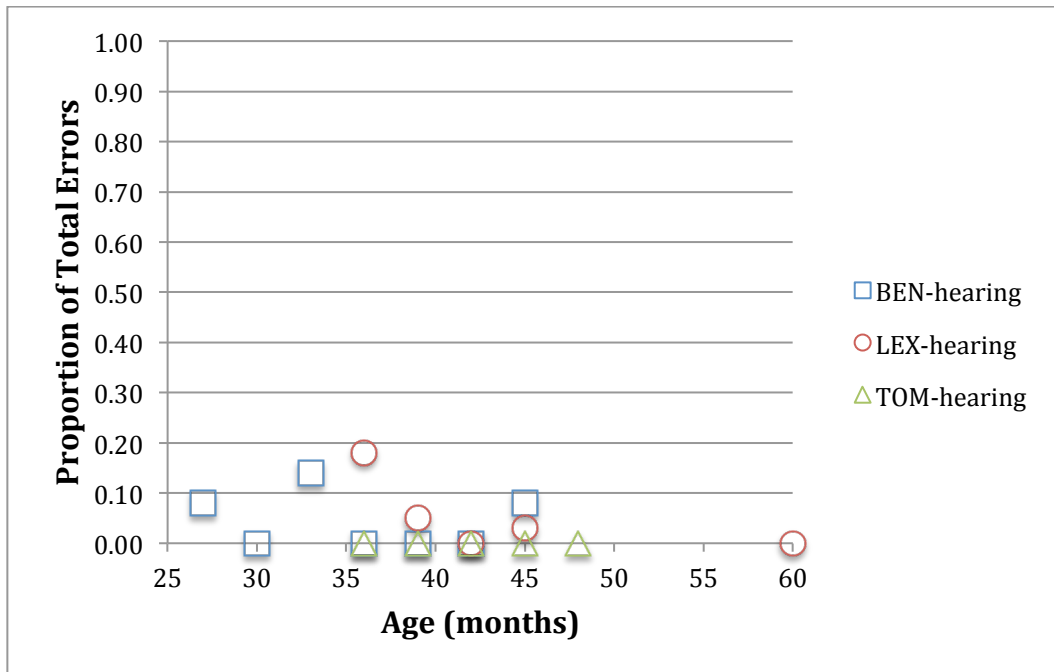
Because all utterances were included, whether the child used code-blending or English only, it is important to determine whether the error rate differed depending on the utterance type. Figure 2.1 shows that almost none of the morphemes used for this analysis were produced in bimodal utterances, while Figure 2.2 shows a similarly small number of the morphological errors these children made were in bimodal utterances. Figure 2.3 compares accuracy rates for morphemes produced in speech only and in bimodal utterances. Over time, both bimodal and speech only utterances improved in accuracy, but bimodal utterances seem to improve more quickly. Additionally, as children grow older, they produce fewer and fewer bimodal utterances



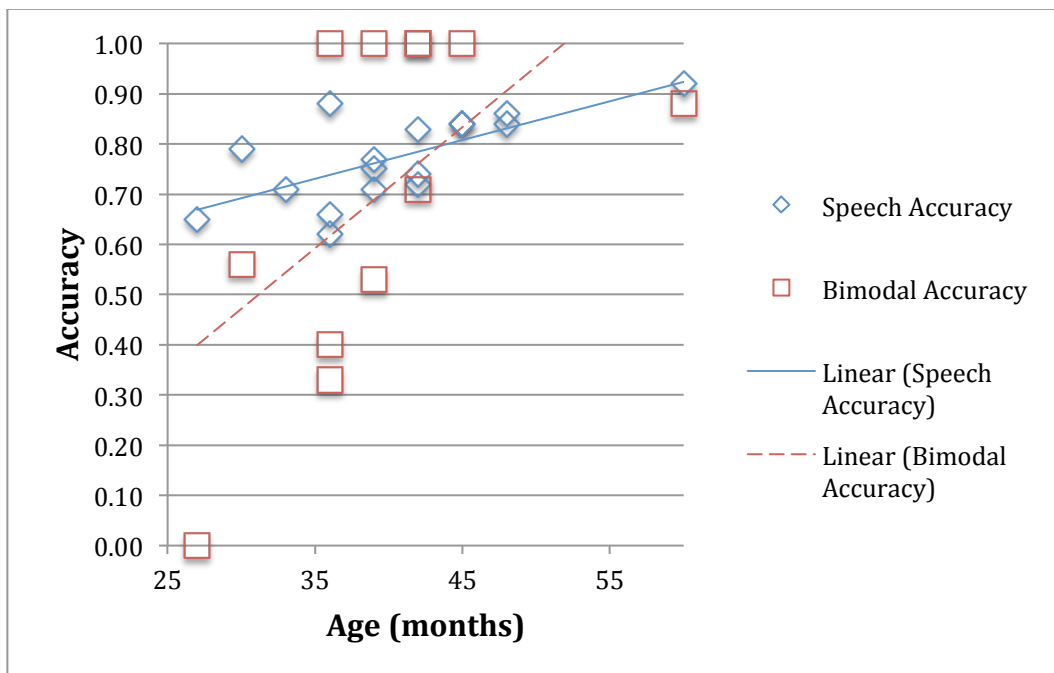
in target English sessions. This is likely due to a number of factors, such as growing English dominance and proficiency and greater sensitivity to the language of the interlocutor.



**Figure 2.1: Hearing Bimodal Bilinguals' Proportion of Morphemes in Bimodal Modality**



**Figure 2.2: Hearing Bimodal Bilinguals' Proportion of All Errors Produced Bimodally**



**Figure 2.3: Hearing Bimodal Bilinguals' Accuracy by Utterance Type**

Davidson et al. (2013) investigated the influence of language context on hearing bimodal bilingual children's accuracy rates with English determiners by comparing their performance in English target sessions to ASL target sessions. These data are drawn from the same corpus and even some of the same children and sessions as this dissertation. Table 2.9 shows that performance was much worse in ASL sessions. In these sessions, speech typically occurred simultaneously with signing and was often whispered rather than fully voiced. The Cantonese-English bilingual data is also included because Cantonese is typologically similar to ASL and therefore, similar transfer effects may be observed. Accuracy rates in this population are noticeably lower, a discrepancy Davidson et al. (2013) hypothesized to be caused by differences in the language environments of the two groups. The Cantonese-English bilinguals were being raised in a majority Chinese-speaking environment, while English is the majority language for the bimodal bilinguals.

**Table 2.9: Determiner Accuracy for Hearing Bimodal Bilinguals' English and ASL Target Sessions, Cantonese-English Bilinguals' English Sessions and One Monolingual English Child**

Age	English Target	ASL Target	Cantonese Bilingual	English Monolingual
3;00	0.80	0.21	0.77	0.87
3;06	0.94	0.20	0.65	0.98
4;00	1.00	0.82	0.66	1.00
5;00	0.98	0.97	0.83	-
6;00	1.00	0.75	-	-

**Table 2.10: Language Modality for Hearing Bimodal Bilinguals' English and ASL Sessions**

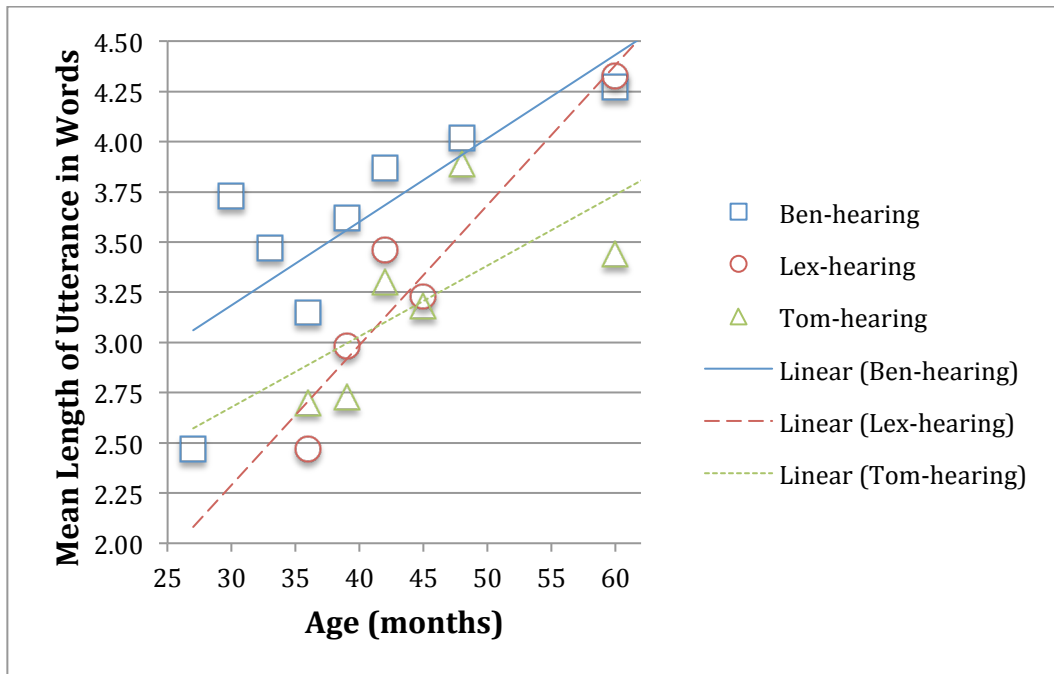
Age	Target Language	Total Utterances	Total English Utterances	Total ASL Utterances	Total Bimodal Utterances
3;00	English	322	286	3	33
3;00	ASL	178	16	71	91

Table 2.10 shows that, even at only three years of age, English almost never occurred outside of code-blended utterances in target ASL sessions, whereas speech alone was used almost exclusively in target English sessions. Why there is such a stark difference in the proportion of code-blended utterances in the target English and ASL sessions is not clear, but language dominance could be an important factor (also, see Petroj et al., 2014 for a discussion of why whispering occurs in ASL sessions).

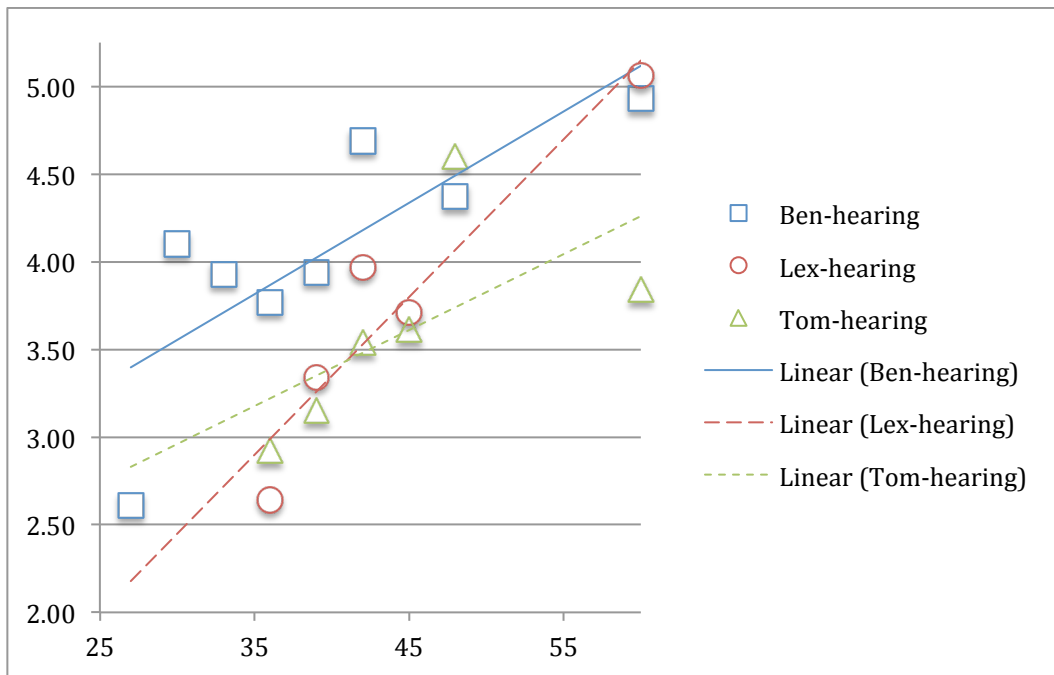
The data from Davidson et al. (2013) and Figures 2.1-2.3 demonstrate three important points: (1) code-blending rarely occurs in target English sessions (2) bilingualism effects are minimal outside of code-blended utterances (3) very few morphological errors occurred in code-blended utterances. For these reasons, data from all utterances types produced in target-English sessions, except ASL only, are included in the following sections.

### **2.4.2 Mean Length of Utterance**

Figures 2.4 and 2.5 below show the participants' MLU in words and morphemes. As can be seen in the graphs, there is a gradual increase in MLU over time, as would be expected. The rate of MLU increase varies from child to child, as can be seen in the linear trend lines of the figures below.



**Figure 2.4: Hearing Bimodal Bilingual's MLU in Words by Chronological Age**



**Figure 2.5: Hearing Bimodal Bilinguals' MLU in Morphemes by Chronological Age**

Thordardottir (2014) collected MLU data from monolingual English speakers and three groups of French-English bilinguals at ages 3;00 (36 months) and 5;00 (60 months). The bilinguals were split based on how much relative exposure they had to each language (more English, equal English/French and more French). The only difference she found among the groups was that the five-year-old bilinguals with more exposure to French had a lower MLU than both the five-year-old monolingual English speakers and the bilinguals with equal exposure to both languages (marked by \* in Table 2.11, based on Thordardottir's Table II). Comparing the hearing bimodal bilinguals' MLU results (Table 2.12) to Thordardottir's data, all three bimodal bilinguals are within one standard deviation of the mean for the monolingual English group at both age ranges. This shows that bimodal bilinguals with relatively equal exposure to both languages can be expected to have MLU values within the normal range found for monolinguals, although sometimes at the lower end (e.g., Lex at 36 months or Tom at 60 months).

**Table 2.11: Thordardottir's MLU Results**

	<b>Monolingual English</b>	<b>More English</b>	<b>Equal English/French</b>	<b>More French</b>
<b>36 months</b>	2.95 (.77)	2.97 (.95)	2.46 (.68)	2.28 (.63)
<b>60 months</b>	4.15 (1.16)	3.85 (.89)	3.77 (.99)	2.95 (.86)*

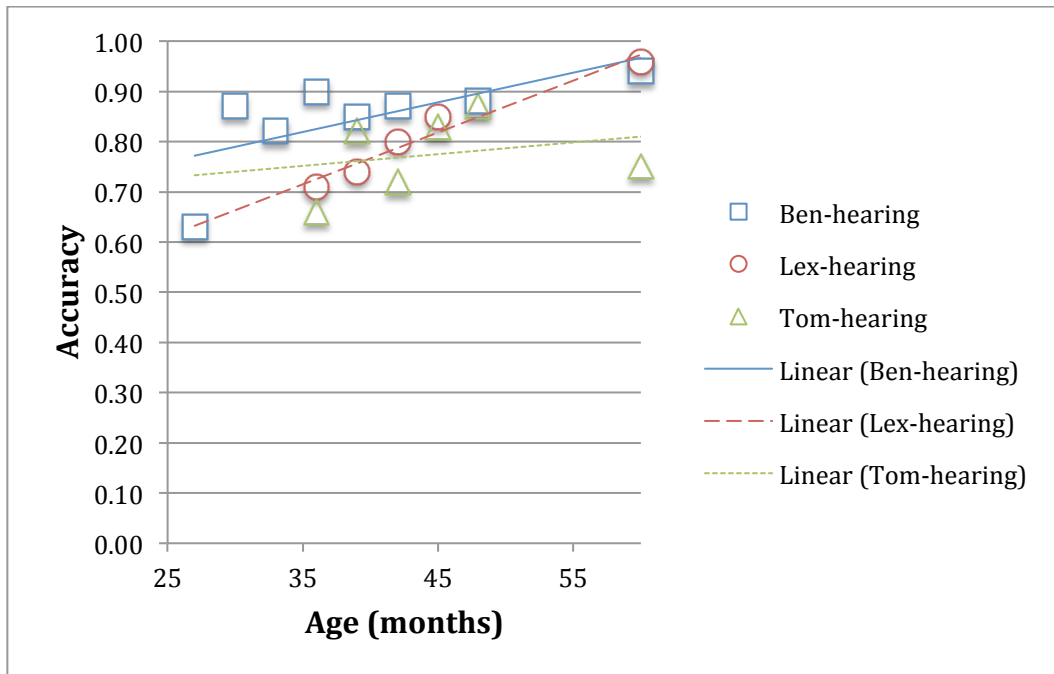
**Table 2.12: Hearing Bimodal Bilinguals' MLU<sub>w</sub> at 36 and 60 months**

	<b>Ben</b>	<b>Lex</b>	<b>Tom</b>
<b>36 months</b>	3.15	2.47	2.70
<b>60 months</b>	4.27	4.33	3.44

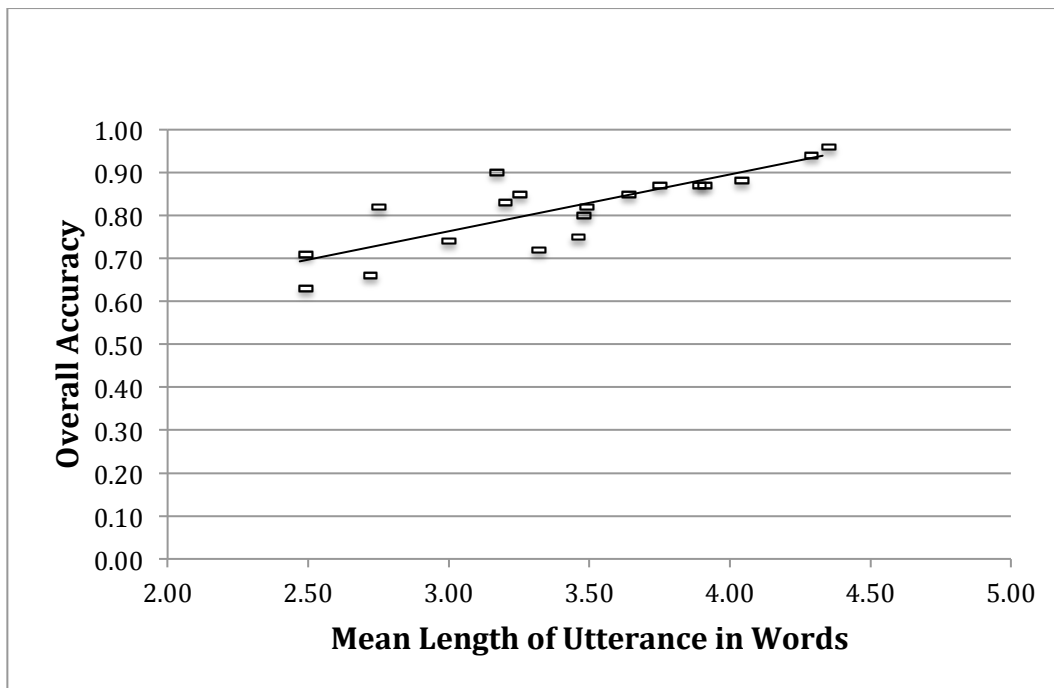
### 2.4.3 Overall Accuracy

This section discusses overall accuracy rates and includes errors of commission as well as omission. This inclusion raised accuracy rates because all instances of verbs, nouns and noun phrases (excluding pronouns) needed to be counted as possible sites for incorrect usage of verbal morphology, plural marking or determiners, respectively. As can be seen in Figure 2.6, overall accuracy increased for all three children as they aged, although this increase occurred at different rates. Figure 2.7 collapses across all three children to show that, as  $MLU_w$  increases, overall morphological accuracy also increases. This demonstrates that as general grammatical complexity increases, morphology is used more accurately.

While the trend for improvement is also clear for all three participants' verbal accuracy (Figure 2.8), Tom's performance with determiners and plurals (Figures 2.9 & 2.10) plateaus, or possibly even worsens. This downward trend is due to his poor accuracy in only one session at 5;00 (60 months).

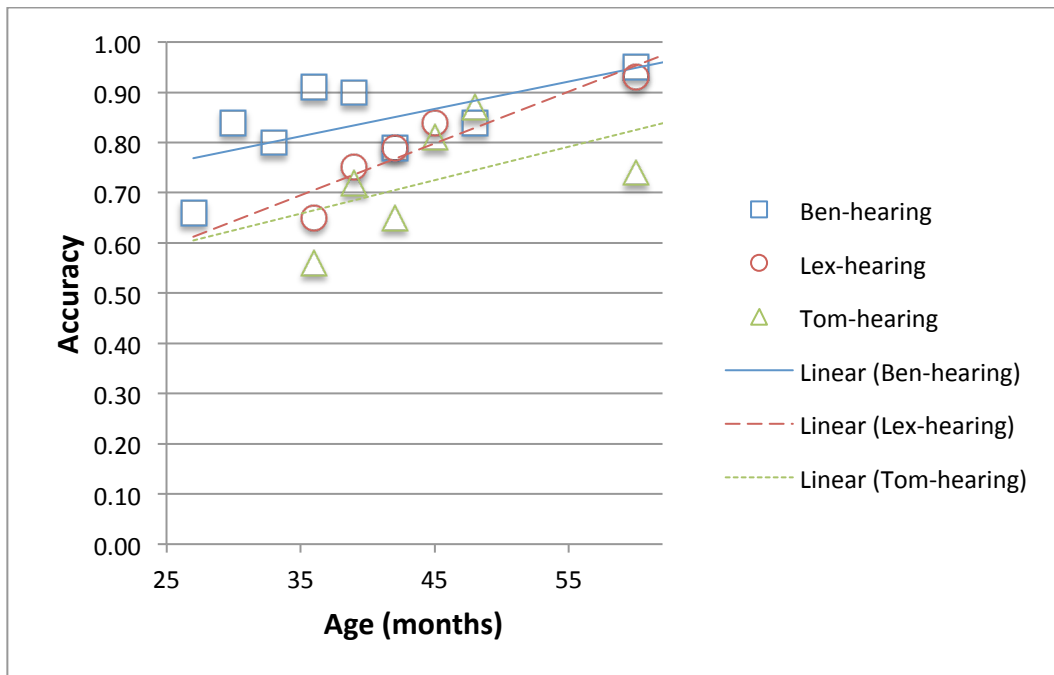


**Figure 2.6: Hearing Bimodal Bilinguals' Overall Accuracy by Chronological Age**

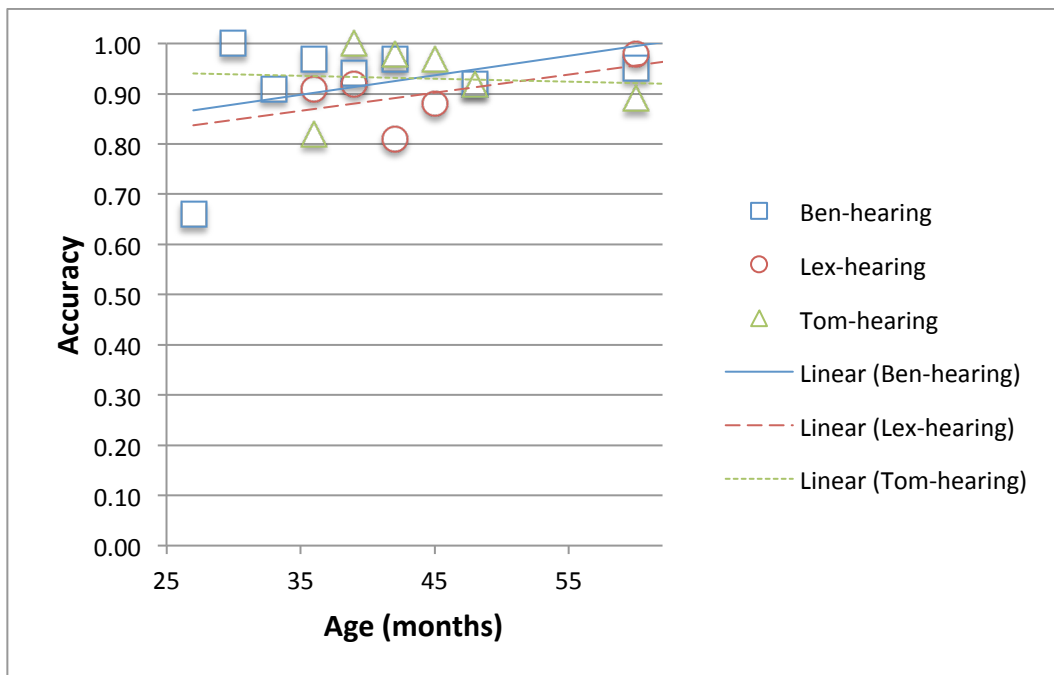


**Figure 2.7: Overall Accuracy by MLU<sub>w</sub> for Hearing Bimodal Bilinguals**

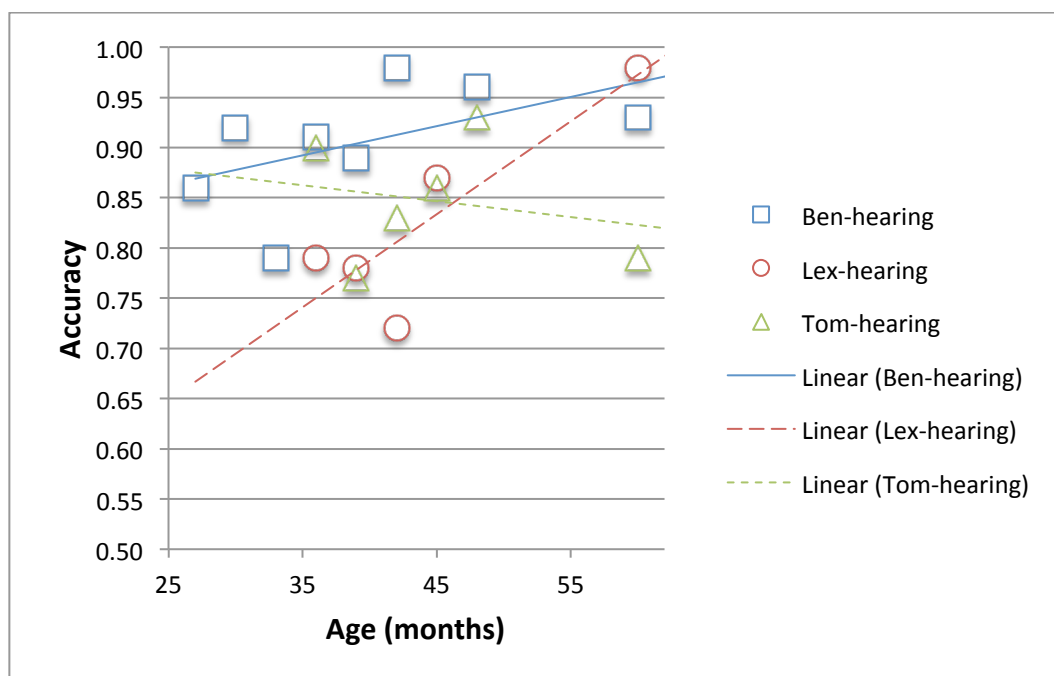




**Figure 2.8: Hearing Bimodal Bilinguals' Overall Verb Accuracy by Chronological Age**



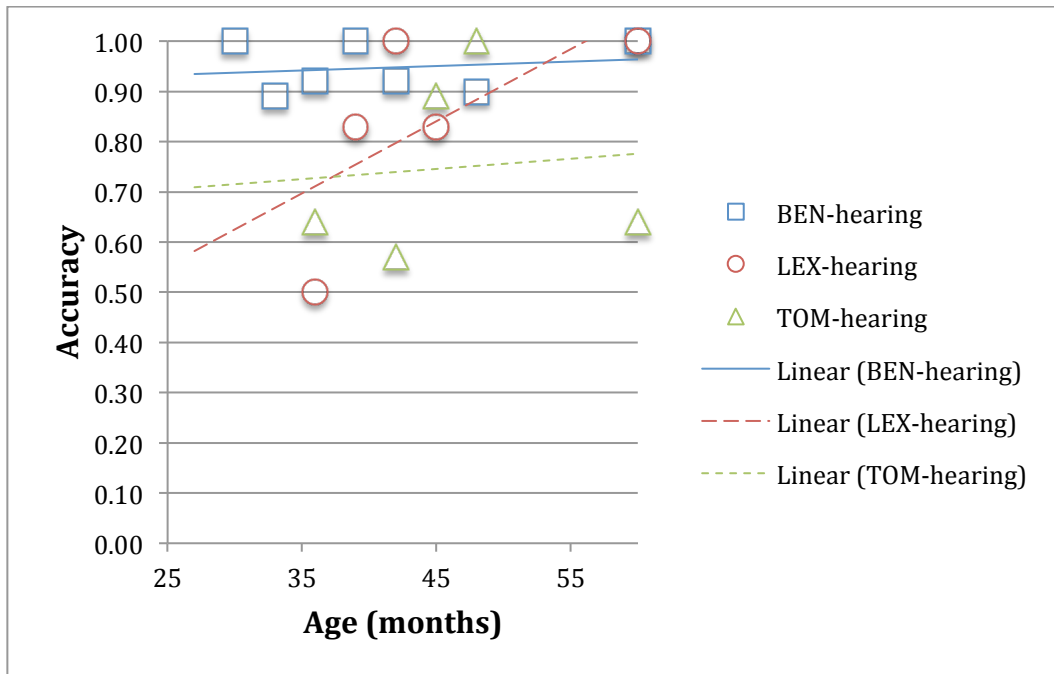
**Figure 2.9: Hearing Bimodal Bilinguals' Overall Plural Accuracy by Chronological Age**



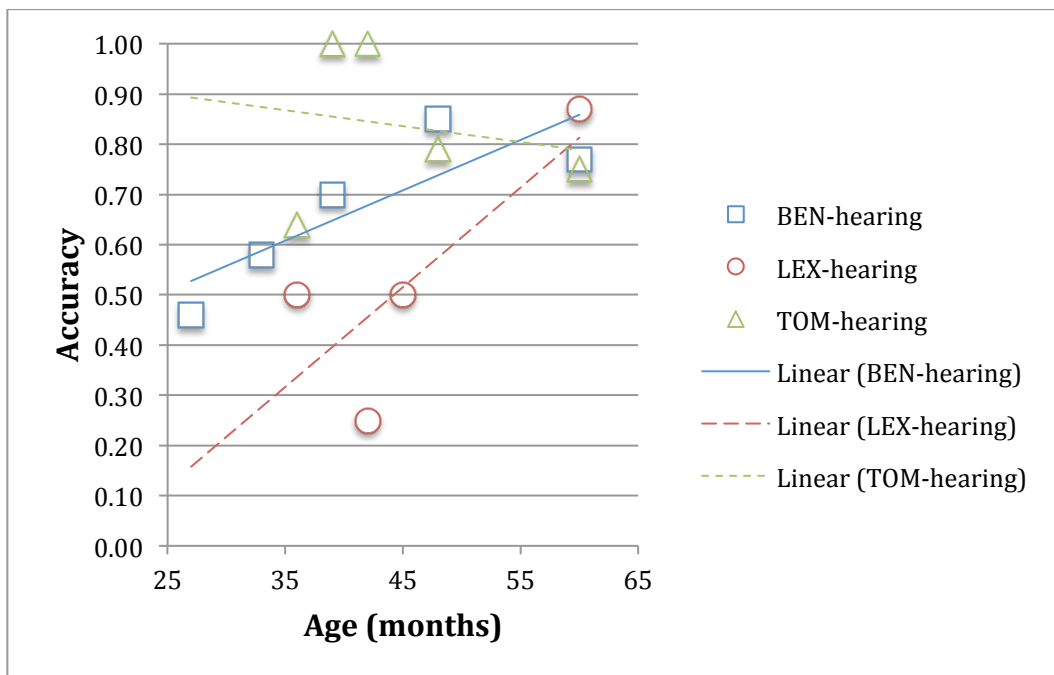
**Figure 2.10: Hearing Bimodal Bilinguals' Overall Determiner Accuracy by Chronological Age**

## 2.4.4 Individual Morpheme Performance

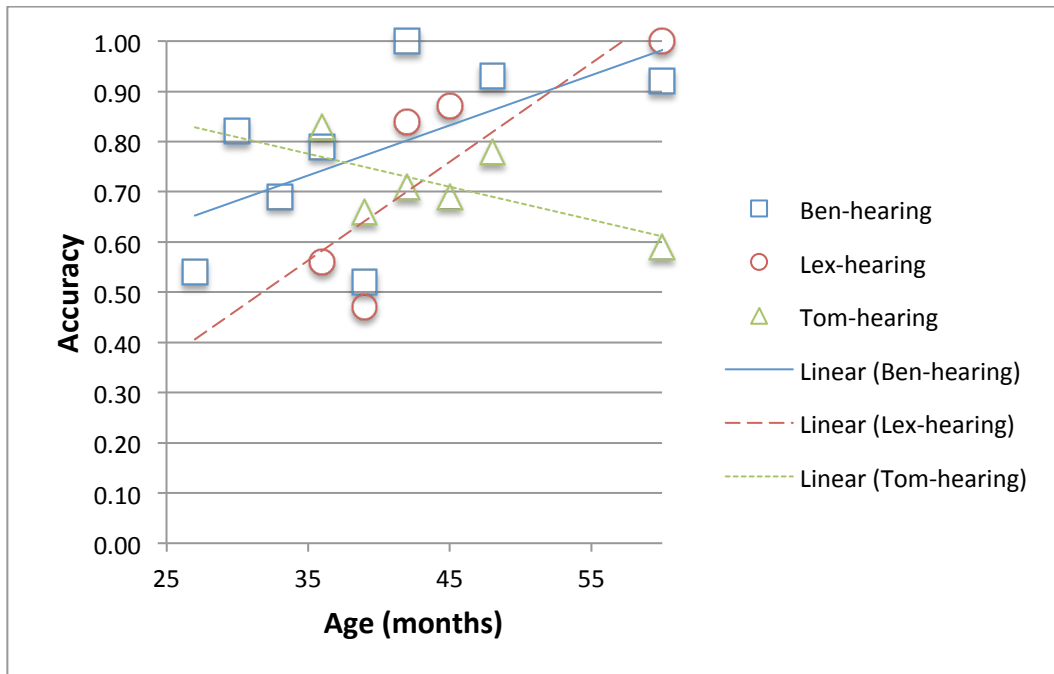
In this section, only the accuracy of morpheme use in obligatory contexts was considered, excluding the possibility of errors of commission and pragmatic errors. This was done in order to best compare with previous research. When the data was broken down into individual morphemes, many morphemes did not reach the minimum number of four obligatory contexts in numerous sessions. Figures 2.11-2.15 presented the data for progressive *-ing*, regular plural, determiners, contractible copula and contractible auxiliary *be*. As the linear trend lines show, most children used most morphemes more accurately as they aged.



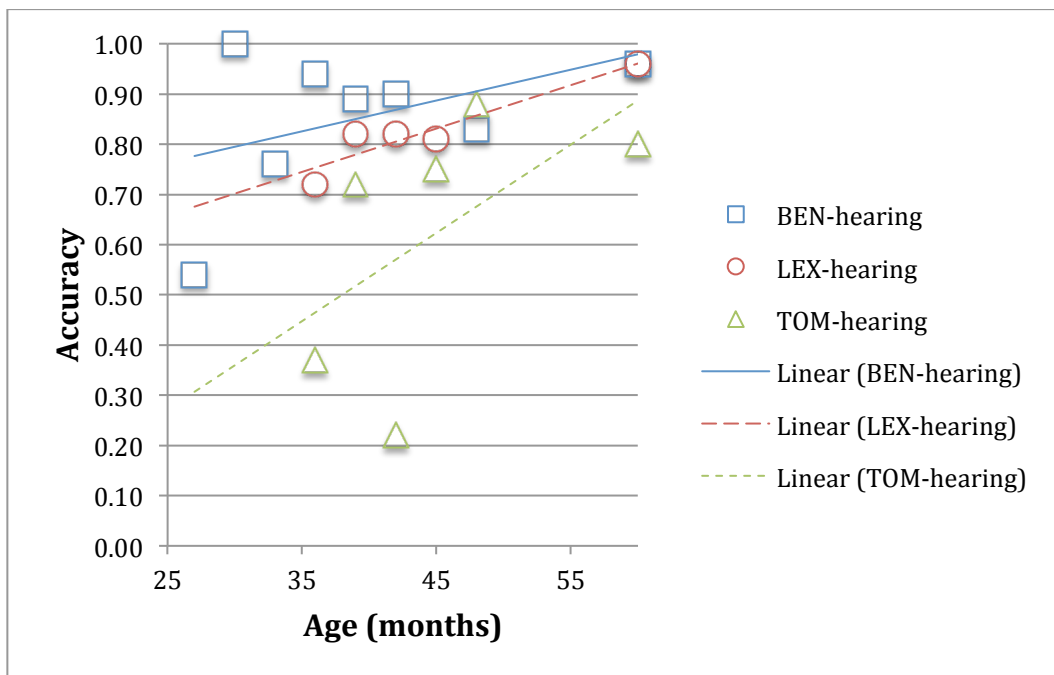
**Figure 2.11: Hearing Bimodal Bilinguals' Accuracy with Progressive *-ing***



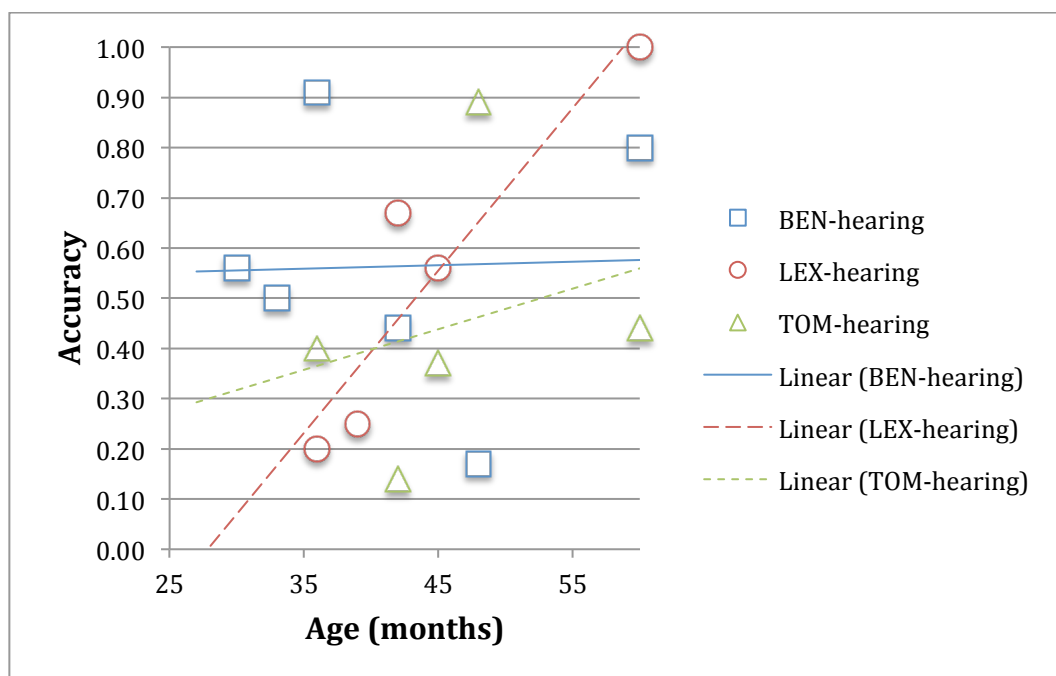
**Figure 2.12: Hearing Bimodal Bilinguals' Accuracy with Regular Plurals**



**Figure 2.13: Hearing Bimodal Bilinguals' Accuracy with Determininers**



**Figure 2.14: Hearing Bimodal Bilinguals' Accuracy with Contractible Copulas**



**Figure 2.15: Hearing Bimodal Bilinguals' Accuracy with Contractible Auxiliaries**

Using a simple criterion for mastery of one transcript with an accuracy rate over 90%, based on the limited amount of data in this study, Table 2.13 shows the age of mastery of each morpheme for each child. It is important to note that mastery could occur during the 12-month data gap from 48 to 60 months. Also, although the criterion used here is different from that of Brown (1973) in that it did not require criterion performance in three consecutive transcripts, performance in these children was relatively stable once criterion was reached. For ease of reading, morphemes that were not considered in this study, as well as morphemes that did not reach the minimum of four obligatory contexts in numerous samples, are omitted from the table.

**Table 2.13: Hearing Bimodal Bilinguals' Age of Acquisition of Grammatical Morphemes**

<b>Morpheme</b>	<b>Ben</b>	<b>Lex</b>	<b>Tom</b>
progressive <i>-ing</i>	36	42	48
plural	did not reach criterion	did not reach criterion	39
articles <i>a(n)/the</i>	42	60	did not reach criterion
contractible copula	36	60	did not reach criterion
contractible auxiliary	36	60	did not reach criterion

**Table 2.14: Monolinguals' Age of Acquisition of Grammatical Morphemes**

<b>Morpheme</b>	<b>Lahey et al.</b>	<b>Adam</b>	<b>Sarah</b>	<b>Eve</b>
<b>progressive - <i>ing</i></b>	35	30	34	21
<b>plural</b>	29	30	34	23
<b>articles <i>a(n)/the</i></b>	N/A	38	37	<i>did not reach criterion</i>
<b>contractible copula</b>	35	<i>did not reach criterion</i>	<i>did not reach criterion</i>	<i>did not reach criterion</i>
<b>contractible auxiliary</b>	<i>did not reach criterion</i>	<i>did not reach criterion</i>	<i>did not reach criterion</i>	<i>did not reach criterion</i>

Comparing the data in Table 2.2 (condensed and repeated above as Table 2.14) to Table

2.13

suggests that Tom and Lex might be showing delayed acquisition of the progressive *-ing*. Similarly, Ben and Lex never reached criterion for plural *-s* morphemes, while this morpheme was mastered quite early by both Lahey et al. (1992) and Brown's (1973) subjects. All three hearing bimodal bilinguals master the English articles later than Adam and Sarah. It is important to note that for regular plurals, four or more unambiguously obligatory contexts occurred in roughly half of Ben's transcripts. Therefore, his delay might be due to a sampling error. All but one of Lex's transcripts had four or more obligatory plural contexts, so this explanation is less likely for his delay.

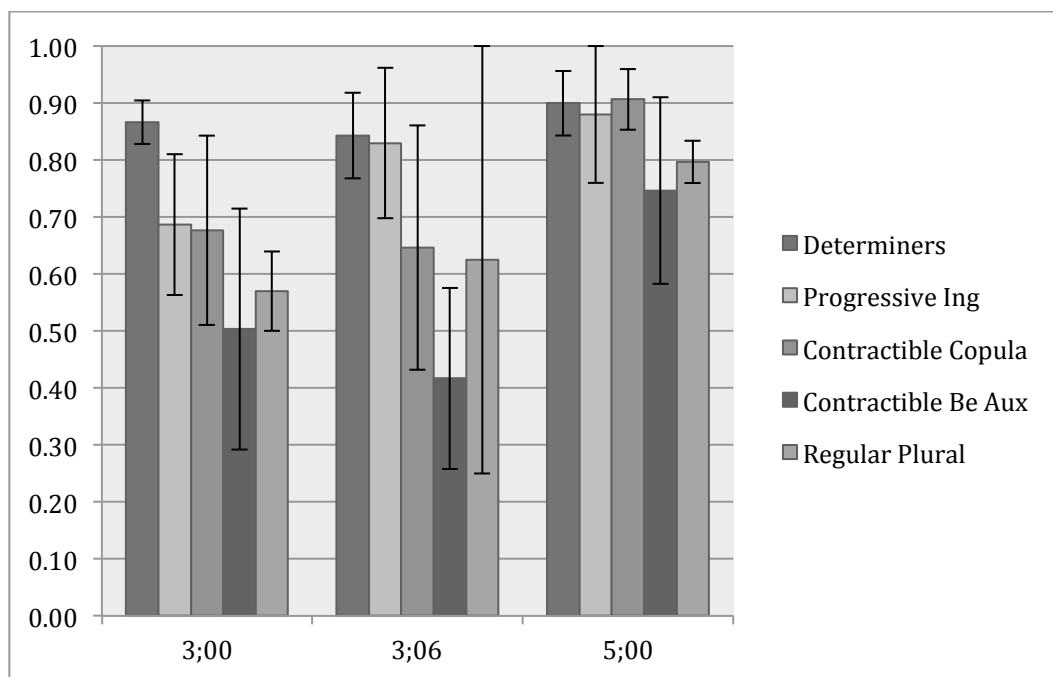
Table 2.15 provides the range of performance for the twenty-one 35 month olds in Lahey et al.'s study and the exact accuracy rates of the three bimodal bilinguals at 36 months old for comparison. At 33 months, Ben's accuracy rate for plural *-s* was .58 and at 39 months his accuracy was .70, while at 36 months there were not enough plural contexts. Neither of these two values is within the range found by Lahey et al (1992). Table 2.15 suggests that while only Tom seems to have difficulty with the contractible copula, all three bimodal bilinguals encountered issues with the English plural *-s* and that this morpheme is particularly vulnerable.

**Table 2.15: Accuracy for Grammatical Morphemes at 3;00**

<b>Morpheme</b>	<b>Lahey et al.</b>	<b>Ben</b>	<b>Lex</b>	<b>Tom</b>
progressive <i>-ing</i>	.50-1.00	0.92	0.50	0.64
plural	.82-1.00	N/A	0.50	0.64
article <i>a(n)/the</i>	N/A	0.79	0.56	0.83
contractible copula	.55-1.00	0.94	0.72	0.37
contractible auxiliary	.14-1.00	0.91	0.20	0.40

## 2.4.5 Perceptual Salience Hypothesis

The predictions of the perceptual salience hypothesis were considered at age 3;00 (36 months), 3;06 (42 months) and 5;00 (60 months). These ages were chosen because data was available for most children and most morphemes at these time points. Average accuracy on each morpheme is presented in Figure 18, with the morphemes in order of decreasing saliency (left to right). It appears that perceptual salience might have been important to some extent at ages 3;00 and 3;06, because performance decreased along with saliency, although the error bars show that there is large variation across children. Any influence saliency had appears to fade by age 5;00. More subjects are necessary to fully address this issue.



**Figure 2.16: Hearing Bimodal Bilinguals' Accuracy by Morpheme in Order of Perceptual Salience at 3;00, 3;06 & 5;00**



## 2.4.6 Section 2.4.6 Error Type Frequencies

Error types fell into four main categories: omission, commission, over-regularization and other. As discussed in the Section 2.3.4 above, omission is the absence of a morpheme in an obligatory context. Commission is inclusion of a morpheme in a context that does not require it. These two error types could have occurred for verbs, plurals and determiners. Over-regularization errors were only possible for irregular verbs and nouns. The “other” category included all errors that did not fit into the other three categories, mostly errors of verb choice.

Examples 1-11 below illustrate actual errors made by the children in this study. Most examples did not occur with any ASL signs or points. When these did occur, signs appear in all capital letters below the spoken utterance and boxes are used to mark signs/gestures and English words that were simultaneously produced. The child’s age appears in parentheses after the pseudonym. Examples 1 and 2 show verb commission errors, while Examples 3 and 4 show plural commission errors. Example 5 shows an error of past tense omission and Examples 6-8 show determiner omission errors. Over-regularizations are illustrated for verbs and nouns in Examples 9 and 10, respectively. The final example, 11, shows an error that was categorized as other and might more specifically be called an error of verb choice.

<u>Commission Errors</u>	
<u>Utterance</u>	<u>Free Translation</u>
<b>Example 1</b>	
Adult: put the strawberries/	Put the strawberries...
Ben(2;03): here you goes	Here you go.
Ben(2;03): here strawberry	Here are the strawberries.
Adult: thank you	Thank you.

### Example 2

Lex(3;06): help looking for that

Lex(3;06): help  
HELP

Adult: help

Adult: what are we looking for

Help me look for that.

Help me.

Help?

What are we looking for?

### Example 3

Ben (2;03): ball, make a balls

Adult: Look. Want me to make a ball for you?  
you?

Ben (2;03): yes  
nods head

Make a ball.

Do you want me to make a ball for

Yes.

### Example 4

Adult: I think we just need one right

Tom(3;00): we don't need ones

Adult: you want one or you want both of them

Tom(3;00): both of them

I think we just need one, right?

We don't need one.

Do you want one or both of them?

Both of them.

### Omission

### Example 5

Ben(2;03): he step in the ball

Ben(2;03): more ball please

Adult: okay

He stepped in the ball.

More balls please.

Okay.

### Example 6

Ben(2;03): truck's over there  
points off camera

Adult: You hear a truck over there?

Adult: Think it's a car.

Ben(2;03): Is truck over there.  
points off camera

There's a truck over there.

You hear a truck over there?

I think it's a car.

It's a truck over there.

### Example 7

Lex(3;06): that same

Lex(3;06): that's the same color

That's the same.

That's the same color.

### Example 8

Adult: what is it

Tom(3;03): flower[?]

What is it?

A flower.

Adult: yellow  
 Adult: what  
 Tom(3;03): it's orange flower

Yellow?  
 What?  
 It's **an** orange flower.

### Over-regularization

#### **Example 9**

Lex(5;00): mines is way too fast  
 Adult: um yeah  
 Lex(5;00): you **losed**

Mine is way too fast.  
 Yes.  
 You lost.

#### **Example 10**

Ben(4;00): because they're bad boys to shoot another  
 Brother: because they're bad boys to shoot another person  
 Ben(4;00): yup  
 Ben(4;00): **peoples** not persons

Because they're bad boys to people  
 shoot other people.  
 Because they're bad boys to shoot  
 another person!  
 Yes.  
 It's "peoples" not "persons."

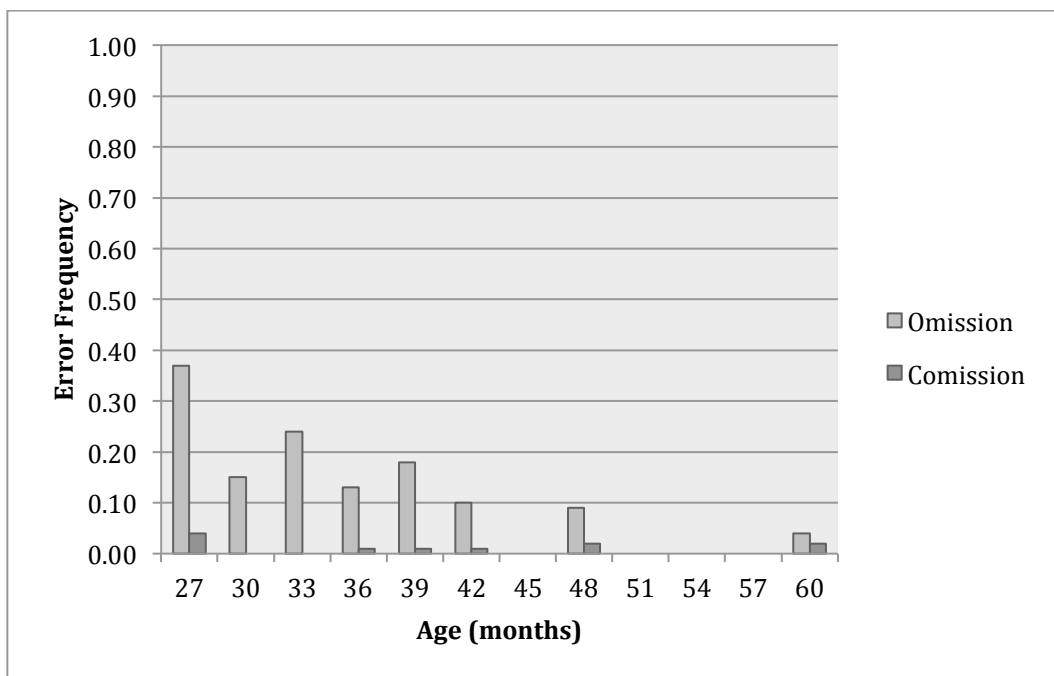
### Other

#### **Example 11**

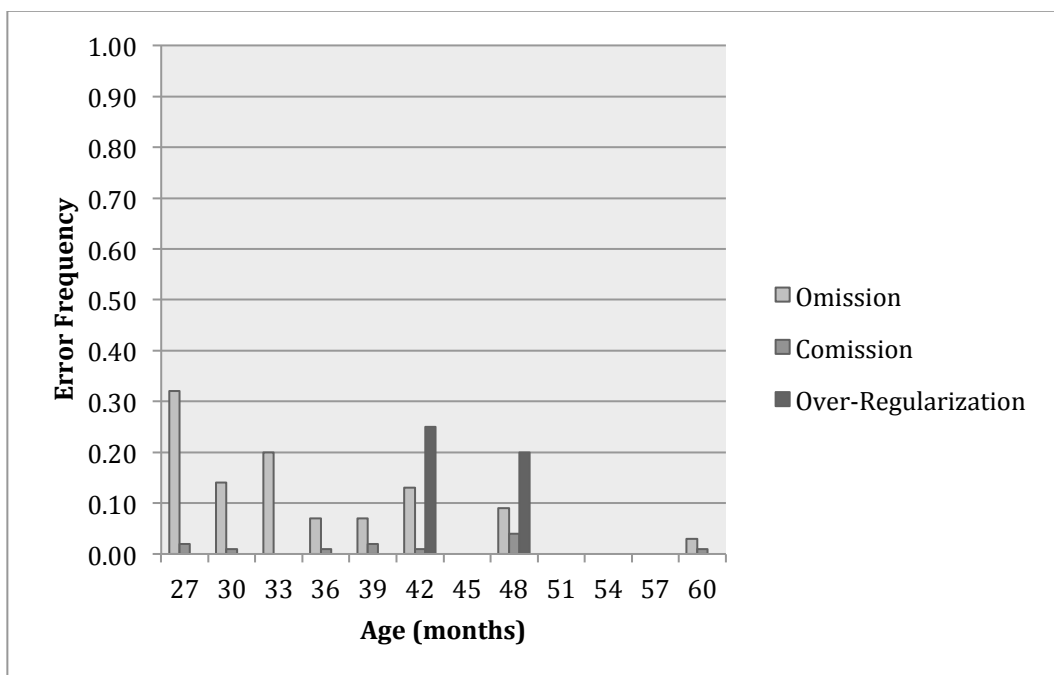
Adult: you have four pockets  
 Adult: one two three four  
 Tom(3;00): I have two  
 Adult: four  
 Tom(3;00): **I'm not**  
 Adult: yeah you have four pockets

You have four pockets.  
 One, two, three, four.  
 I have two.  
 Four.  
 I don't.  
 Yes, you have four pockets.

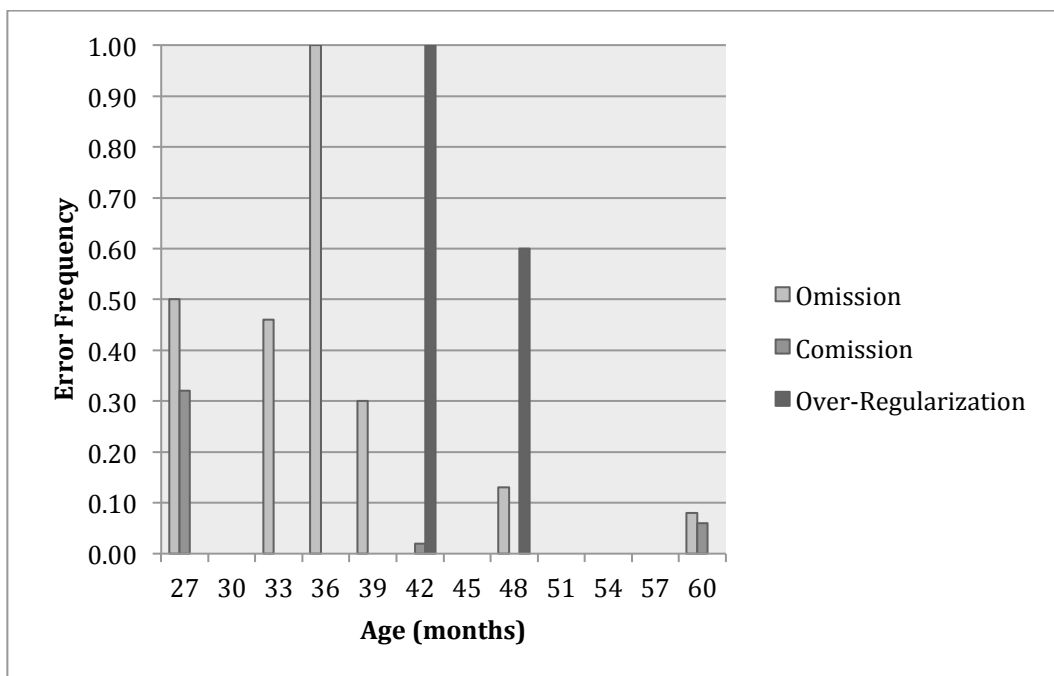
Figure 2.17 illustrates Ben's overall error pattern in which errors of omission are much more common than errors of commission (data from the other two children are provided in Appendix C). Figures 2.18 and 2.19 show a similar pattern when the data is broken down for verbs and plurals. They also show a possible upside down U-shaped pattern for over-regularization errors, but the data is too sparse to show a clear pattern. Generally, the types of errors that the hearing bimodal bilinguals made were the same as those observed in monolingual English speakers. Figure 2.20 shows no clear pattern for pragmatic errors, beyond a general trend toward reduced frequency across time.



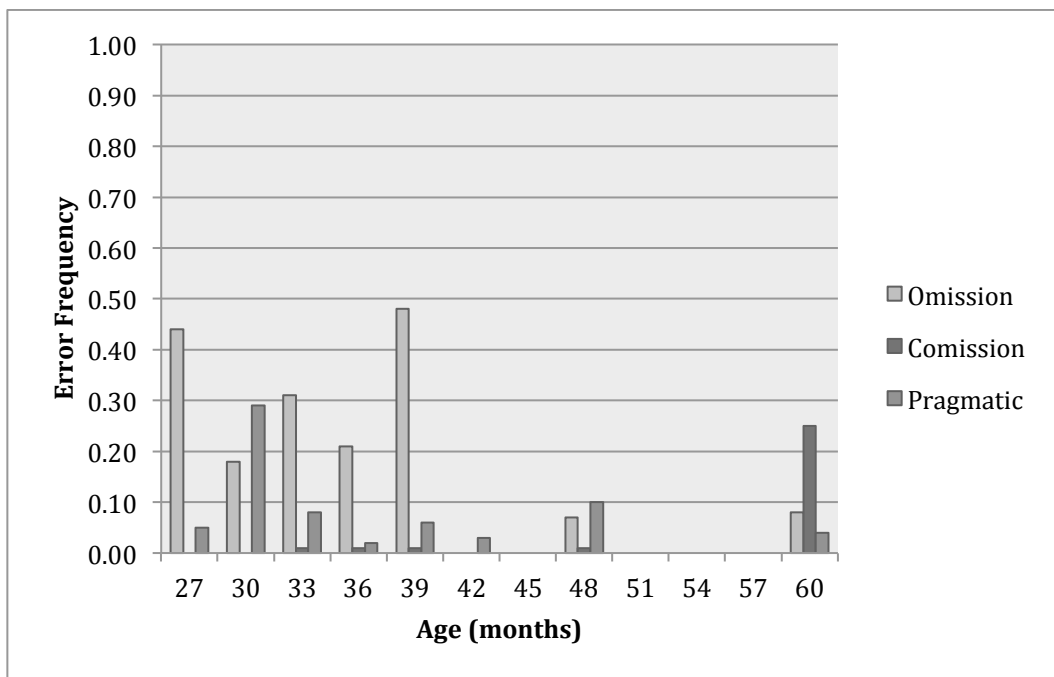
**Figure 2.17: Ben's Overall Error Type Frequencies**



**Figure 2.18: Ben's Overall Verb Error Type Frequencies**



**Figure 2.19: Ben's Overall Plural Error Type Frequencies**



**Figure 2.20: Ben's Overall Determiner Error Type Frequencies**

## 2.5 Discussion

As discussed in sections 2.4.2 and 2.4.3, MLU in words and morphemes gradually increased over time and overall accuracy rates increased as MLU in words increased, as would be expected for monolinguals. When compared to the group averages presented in Thordardottir (2014), MLU values are within the range observed in the monolingual groups, albeit sometimes on the lower end. If MLU is a good measure of overall grammatical development, we should expect similar results for the acquisition of grammatical morphemes as well.

When morphemes were considered individually, unfortunately our minimum of four obligatory contexts reduced the amount of data available for comparison. Yet this minimum did help insulate the results from wild fluctuations due to insufficient data. While the age of acquisition seems higher for the bimodal bilinguals than the ages presented for monolinguals in previous research, the accuracy of most morphemes falls within the range expected based on Lahey et al. (1992). Furthermore, the age gap of data from 4;00 to 5;00 might artificially inflate the ages of acquisition for one of the bimodal bilinguals (Lex) because he demonstrated mastery of four out of the six morphemes in his final transcript at 5;00, and may even have mastered these morphemes earlier.

Despite these caveats, the English plural morpheme *-s* seems to be particularly vulnerable to input factors and/or transfer effects from ASL. As discussed in Section 2.1.4, plural marking in ASL is optional, and when present, often takes the form of noun reduplication. This method of plural marking is very different from the English system. One interesting follow up to these findings would be to check each instance of English plural omission to see if some form of

reduplication in speech (or perhaps code-blended sign) was used as an alternative means of marking plurality.

Another factor that conspires against the English plural is its low perceptual saliency. As discussed in Section 2.4.5, perceptual salience seemed to influence performance at least at the ages 3;00 and 3;06. The plural *-s* is one of the least salient morphemes considered in this study, and also one that seemed to present these hearing bimodal bilinguals with difficulty when compared to monolingual English speakers.

Error type frequencies were very similar to what has been observed in monolinguals. Omission errors were much more common than commission errors at all time points. This is not only consistent with monolingual norms, but also what would be expected based on the typological characteristics of ASL. Additionally, while over-regularization error data is not inconsistent with a U-shaped developmentally pattern, these errors are uncommon and do not show a clear pattern.

Overall, these hearing bimodal bilinguals performed remarkably similar to monolinguals, despite their reduced English input and the possible influence of ASL. Their generally impressive outcomes could be due to a number of factors. First, they began learning both languages simultaneously from birth and received about equal input in both languages, both factors that have been found to contribute to monolingual-like performance (e.g., Thordardottir, 2014; Paradis et al., 2010). Furthermore, English is the majority language of the communities in which these bilinguals lived, while the minority language has been found to be the most vulnerable (e.g., Unsworth, 2015). The one exception to their overall great outcomes was their consistently poor performance with the English plural marker. This deficit could have been due to a combination of low perceptual saliency and transfer effects from ASL. Future studies should

focus on other English morphemes with low perceptual salience that ASL lacks, such as the past tense *-ed*, to see if this deficit extends beyond this one morpheme.



## **Chapter 3: Morphological Development in Deaf Bimodal Bilingual Children with Cochlear Implants' Spontaneous Speech**

In this chapter, English morphological accuracy in the spontaneous speech of three Deaf bimodal bilingual children with CIs is presented and compared to the hearing bimodal bilingual children's results from the previous chapter. Section 3.1 provides a brief review of relevant literature, while Section 3.2 makes predictions for the subjects based on this literature. Section 3.3 introduces the participants and methodology. Finally, the data from the Deaf bimodal bilinguals is presented and discussed in Sections 3.4 and 3.5.

### **3.1 Background**

#### **3.1.1 Morphological Development in Monolingual Children with Cochlear Implants**

Few studies have looked specifically at the morphological development of monolingual children with CIs, but of those that have, all seem to find morphological deficits. Although there are significant differences amongst the morphological systems across languages, data from Dutch, German and Hebrew will also be discussed because only a handful of authors have looked specifically at English morphological development in this population. Generally, the inflectional morphology of these other three languages is much richer than English, meaning that they use more complex paradigms and/or additional morphological categories.

While much of the broader research on children with cochlear implants has attempted to address the question of whether they catch up to their normal hearing (NH) peers, numerous authors studying morphological development have focused on the perceptual salience hypothesis discussed in Section 2.1.2 above. This is because many grammatical morphemes are not particularly salient and hearing through a CI is very different from acoustic (normal) hearing. For example, high frequencies are relatively well conveyed by a CI, but low pitches are not. Phonemes of short duration and low intensity may not be well represented by the CI, depending of course on the coding strategy and programming of the implant. Hearing in noise is also problematic, so learning by overhearing is less of an option (see Wilson & Dorman, 2009 for an overview of cochlear implant functioning). Although it is not clear to what extent learning by overhearing is relevant to morphological acquisition, researchers have demonstrated that children learn some vocabulary this way (e.g., Akhtar, Jipson, & Callanan, 2001).

Guo, Spencer & Tomblin (2013) used a story retell task with nine children with CIs (all implanted before 2;02) and 27 typically developing NH children at the ages of four, five and six. Children with cochlear implants were followed across time, while typically developing children were split into the three age groups and matched to the CI group based on their hearing age (i.e., duration of implant use). A story retell task was used in which the experimenter showed the child a series of pictures and told a story and then asked the child to look at the pictures again and tell the story themselves. Accuracy of production of third person singular *-s*, past tense *-ed*, copular *be* and auxiliary *be* and *do* was analyzed. Guo et al. (2013) found that children with CIs were behind NH, hearing-age matched peers in verbal morphology development, but that their error types were similar (omission rather than commission). These children were also given speech perception tests at each time point. Poor performance on these tests was correlated with low

morphological accuracy at the following time point, demonstrating the influence of perceptual difficulties on morphological acquisition.

Hammer, Coene, Rooryck & Govaerts (2014) compared production of Dutch verbal morphology in 48 children with cochlear implants (aged 3;09-7;07) to 38 children with SLI (aged 4;00-7;00). All children had received their CIs between the ages of 0;05-3;07. While the children with cochlear implants performed significantly better than the children with SLI, both groups were behind the typically developing, NH controls. In fact, Hammer (2010, Section 5.1) found that Dutch-speaking children with CIs need approximately 44 months of experience with a CI to be within the normal range of finite verbal morphology production for their hearing age. Interestingly, while many of the children with CIs in the Hammer et al. (2014) study had MLUs below NH norms, and low MLU often occurred with low morphological accuracy, 20% of these children produced short but grammatically complex utterances (i.e., containing a finite verb).

Herzberg (2010) studied the acquisition of Hebrew noun plural and verbal morphology in spontaneous speech samples from three children with CIs (all implanted before 1;06) and three NH children matched based on chronological age, hearing age and MLU. The children with CIs were between the ages of 2;02-4;10, while the NH were aged 1;06-3;06. Hebrew uses both concatenative morphology to mark noun plural and verb agreement, as well as stem internal changes to mark verb tense and mood. Herzberg found that children with CIs performed on par with chronological age and MLU matched hearing children and better than hearing age matched children with noun plurals. Performance differed for verbal morphology; children with CIs performed as well as MLU and hearing age matched NH peers, but worse than chronological age matched NH peers. This study demonstrates that children with CIs can do as well as hearing age,

and even sometimes chronological age matched peers, but that performance may vary depending on the specific morphology under consideration.

Svirsky et al. (2002) investigated the role of perceptual salience in morphological acquisition and found that it was more important for children with CIs than NH and children with SLI. The elicited speech of nine children with cochlear implants with a mean age of 6;10 were compared to two groups of NH (mean ages 3;00 and 4;10) and one SLI group (4;09), with nine children in each group. All children with CIs received their implant by 6;11 (mean age 3;08). The NH and SLI groups were most accurate on plural *-s*, followed by copula *be* and worst on past tense *-ed*. For these two groups, factors other than perceptual salience (e.g., frequency) lead to earlier acquisition of plural *-s*, which has low perceptual salience. For the CI group, performance on plural *-s* was not better than uncontractible copula *be*; in fact, there was a non-significant trend toward better performance on uncontractible copula *be*, which is more perceptually salient than plural *-s*. Again, performance on regular past tense was the worst. This pattern of lower performance on the low-salience plural *-s* was interpreted as evidence in support of the perceptual salience hypothesis.

Ruder (2004) argued that perceptual salience is not more important than semantic complexity for children with CIs and that they acquire English morphemes in the same order as hearing children. Picture stimuli were used to elicit plural and third person singular *-s* and copula and auxiliary *is* from nine children with CIs aged 4;00-8;00, as well as comparison NH and SLI groups. While all groups were more accurate with the more salient *is* than *-s*, the children were also all less accurate with third person singular *-s* than plural *-s*. Performance across groups was not statistically compared. Overall, these results seem to demonstrate that other developmental

factors, such as so-called semantic complexity and possibly input frequency, are important to children with cochlear implants as well.

Szagun (2004) analyzed the use of German articles in spontaneous speech samples of nine children with CIs (all implanted before 3;10, mean age 2;03) and six normal hearing children ranging in age from 1;04-7;00. The children were matched based on MLU in order to ensure that overall levels of grammatical development were similar. Szagun found that children with cochlear implants made more errors than normal hearing peers and that, although perceptual salience was important for both groups, it seems to be more important for children with cochlear implants. While children with cochlear implants did not make more mistakes with similar sounding forms than normal hearing children, they were more likely to omit articles in the accusative and dative cases. Szagun hypothesized that this could be because these articles are more likely to be sentence medial and less perceptually salient than those in the nominative case, which often occur at the beginning of a sentence. NH children were more likely to make errors of case or gender rather than omission with these oblique forms.

On the other hand, Hammer (2010, Section 5.2) found that perceptual prominence did not seem as important to the morphological development of children with CIs as it was for children with SLI. Accuracy producing the Dutch past participle, which consists of *ge*-stem-*t*, in spontaneous speech was analyzed in this study. Final suffix *-t* is less salient than prefix *ge-*, yet the children with CIs omitted the prefix more frequently than the suffix. This pattern was reversed in the SLI group, suggesting that perceptual prominence was important in this group, but not for the children with CIs.

Research across these four different languages has found that morphological difficulties are common in children with CIs, especially when compared with NH children matched based on

chronological age. Although there is some evidence to the contrary, many authors have found the perceptual salience of individual morphemes to be particularly important for these children. Additionally, performance on tests of speech perception was positively correlated with later accuracy in morphological production. All of this evidence suggests that morphological development is slower in children with CIs due to the particular difficulties they have perceiving these small segments through their implants.

### **3.1.2 Acquisition of Variable or Inconsistent Input**

All of the evidence presented in the previous section shows that children with CIs likely do not always perceive the morphemes present in their input, which makes their intake much more variable than that of the NH peers they are often compared to. It is impossible to know exactly what each child with a CI perceives on a daily basis, and it likely varies from child to child based on their particular audiological factors (e.g., presence/absence of cochlear malformations, insertion depth of CI, number of active electrodes, see Section 1.5.3 for more discussion). Yet there are many NH children exposed to variation in their input due to differences in the speech of the input providers (e.g. Smith, Durham & Fortune, 2007; Miller & Schmitt, 2012; Miller, 2012); their language development generally has been understudied because they are exposed to non-standard dialects. This variable input has been found to cause an extended time-course in development compared to consistent input.

The acquisition of variable 3<sup>rd</sup> person *do* agreement in working class children studied by Miller (2012) might be analogous to the learning conditions children with CIs often face. In this variety of English, third person agreement is consistently produced in all contexts except when it

contracts with negation. This means that a working class child will never hear an utterance like “*he do live here,*” but he will probabilistically hear both “*he doesn’t live here*” and “*he don’t live here.*” Miller found that adult speakers of this dialect omitted 3<sup>rd</sup> person agreement when *do* was contracted with negation 55% of the time in their speech with a research assistant who spoke the same dialect.

Miller (2012) hypothesized that these children will go through a stage during which they misinterpret this variable input as inconsistent input, which follows no discernable, predictable pattern. Research by Hudson Kam and Newport (2009) has found that children often systematize when faced with inconsistent input. For those children that received a form 60% of the time with no other alternate forms occurring in the input, this meant over-regularization to zero, or omission. This leads to the prediction that working class children will omit 3<sup>rd</sup> person *do* agreement even in contexts in which it is never omitted in their input, such as in interrogative (e.g., “*do he live here?*”).

In order to test this theory, Miller elicited 3<sup>rd</sup> person singular interrogative questions from both middle class and working class four-year-old children. While neither group was perfectly accurate with 3<sup>rd</sup> person singular agreement, the middle class children produced *do* agreement significantly more often (72.91%) than the working class children (42.18%). Furthermore, most children were systematic in that they consistently produced or consistently failed to produced 3<sup>rd</sup> person agreement. These results are consistent with Miller’s theory that the children with variable input over-regularized to zero.

Returning to the challenges children with cochlear implants must confront, variable input might lead them to omit morphemes more frequently than NH peers who receive consistent input. Of course, omission errors are also the most frequent error type for NH children as well, so

a predominance of other error types would be surprising. Yet, while grammatical morphemes should be perceived more easily in ideal rather than adverse listening conditions, input variability likely would not follow any particular linguistic pattern. Therefore, the type of input children with CIs receive might be better characterized as inconsistent, rather than variable input.

This leads to the question of whether these children will ever outgrow the “over-regularize to zero” stage and achieve adult-like usage rates. Ideally, the progress of children with morphological deficits should be followed over time, well beyond the typical acquisition period to allow them sufficient time to catch up to NH peers. Theoretically, there are at least two ways children with CIs might overcome the problem of inconsistent input: (1) better programming of the implant combined with neurological adaptations leads to better speech perception; (2) implicit recognition of hearing deficits leads to “filling in” of perceptually absent morphemes. This study analyzed the morphological production of three Deaf bimodal bilingual children with cochlear implants from around the age of three years old to six and a half years of age to determine whether they go through such a stage and, if yes, whether they overcome it by an age when most monolingual children’s morphological errors are exceedingly rare

### **3.1.3 Why Compare to Hearing Bimodal Bilinguals?**

Because bilingual children often follow a different pattern of morphological development than monolingual children and the specific language pair can be influential (see Section 2.1.3), the results from the hearing bimodal bilinguals presented in Chapter 2 will serve as a baseline for comparison with the Deaf bimodal bilinguals with CIs’ results. While these groups are similar on a number of variables (both bilinguals of similar socio-economic status acquiring ASL and



English), there are two main differences that should be pointed out. First, there is a delay in English language exposure for the Deaf group that the hearing group did not experience. Second, all the Deaf children received language therapy as part of their habilitation program. Monolingual deaf children with CIs would be an ideal comparison group in so far as they experience a similar delay in spoken language exposure and also intervention to assist in language development, but they would not experience any effects of bilingualism. Inclusion of such a group was beyond the scope of this project, but should be considered for future work.

### **3.2 Predictions**

Despite the important methodological differences (standardized tests versus language sample analysis), the results from Davidson et al. (2014) discussed in Section 1.5.4 suggest that Deaf bimodal bilinguals with CIs should produce English morphemes with the same accuracy as hearing monolingual English speakers of the same chronological age. Yet, as discussed in the section on bilingual morphological development in Chapter 2, delays are often observed in hearing, unimodal bilinguals with no language disorders. This leads to the more modest prediction that Deaf bimodal bilinguals with CIs perform as well as chronological age matched hearing bimodal bilinguals. Such a comparison has not been made in previous studies of children with CIs. If the delay in English language exposure until after CI activation is integral, hearing age matched bimodal bilingual peers would better serve as a comparison group.

Because hearing with a CI is different from normal acoustic hearing, the perceptual salience of morphemes will be more significant for children with CIs, as discussed in Section 3.1.1 above. This could lead to higher rates of omission due to factors such as over-regularization to zero

(Section 3.1.2). For these reasons, omission rates and order of morpheme acquisition in Deaf bimodal bilinguals with CIs may be more dependent on perceptual salience than in hearing monolinguals and bilinguals. Influence of ASL would likely also lead to higher omission rates (see Sections 2.1.4 & 2.2) than NH monolingual peers, but not in comparison to the hearing bimodal bilinguals who are exposed to the same two languages and serve as our control group.

### 3.3 Method

#### 3.3.1 Participants

Three Deaf children aged 2;10-6;06 given the pseudonyms Eli, Gia and Nik participated in this study. Eli and Nik are brothers (not twins) and Gia is a female not related to Eli or Nik. All children were born deaf to Deaf, signing parents and received their first cochlear implant before age two. They began acquiring ASL from birth and English after implant activation. Table 3.1 provides detailed information about implantation timing and SES. Table 3.2 shows the number of Deaf family members each child has as an indicator of amount of ASL exposure.

**Table 3.1: Background Information for Deaf Bimodal Bilinguals**

<b>Pseudonym</b>	<b>Age at 1st Implant Activation</b>	<b>Age at 2nd Implant Activation</b>	<b>Mother's Education</b>
<b>Eli</b>	1;01	1;11	16
<b>Gia</b>	1;07	N/A	16+
<b>Nik</b>	1;04	3;06	16

**Table 3.2: Deaf Family Members of Deaf Bimodal Bilinguals**

<b>Pseudonym</b>	<b>Mother</b>	<b>Father</b>	<b>Other Deaf Family</b>
<b>Eli</b>	Deaf	Deaf	2 Siblings
<b>Gia</b>	Deaf	Deaf	
<b>Nik</b>	Deaf	Deaf	2 Siblings

All of the Deaf bimodal bilinguals with CIs received speech therapy as part of their habilitation programs. These speech sessions were tailored to the needs of each child, so it is possible that some of the morphemes considered in this study were targeted for improvement. Unfortunately, detailed data was not collected about the type of interventions carried out in speech therapy sessions. While it is not uncommon for hearing bimodal bilinguals to be referred to speech therapists as well, none of the three hearing bimodal bilingual participants from Chapter 2 are known to have received speech therapy.

Other differences in the quantity or quality of language input (ASL or English) from caregivers in the home are conceivable, but not known. Furthermore, it may not be possible to determine whether such differences exist because the filming sessions may not be representative of the typical input a child receives. This is because (1) a hearing or Deaf researcher often interacted with the child rather than a caregiver and (2) knowledge that each session had a “target” language might have influenced language behavior.

### **3.3.2 Data Collection**

Data collection is the same as described in Section 2.3.2. Table 3.3 shows the details of the sessions used for analysis. Unlike the hearing bimodal bilinguals, the Deaf children did not always produce one hundred analyzable utterances in every session. For Nik and Eli, this could be partially due to the fact that all the sessions included both brothers playing with an adult, giving each individual fewer opportunities to talk. Sixteen sessions were used for analysis, with at least four from each child.

**Table 3.3: Deaf Bimodal Bilinguals' Spontaneous Speech Sample Information**

<b>Pseudonym</b>	<b>Status</b>	<b>Language Input</b>	<b>Chronological Age</b>	<b>Hearing Age</b>	<b>Session #</b>	<b>Number of Utterances</b>
Eli	Deaf w/CI	English & ASL	2;10	1;09	1	74
Eli	Deaf w/CI	English & ASL	3;00	1;11	2	92
Eli	Deaf w/CI	English & ASL	3;03	2;02	3	48
Eli	Deaf w/CI	English & ASL	3;05	2;04	4	100
Eli	Deaf w/CI	English & ASL	3;08	2;07	5	100
Eli	Deaf w/CI	English & ASL	4;02	3;01	6	100
Eli	Deaf w/CI	English & ASL	5;00	3;11	7	100
Gia	Deaf w/CI	English & ASL	5;03	3;08	1	90
Gia	Deaf w/CI	English & ASL	5;06	3;11	2	100
Gia	Deaf w/CI	English & ASL	5;10	4;03	3	100
Gia	Deaf w/CI	English & ASL	6;02	4;07	4	100
Gia	Deaf w/CI	English & ASL	6;06	4;11	5	100
Nik	Deaf w/CI	English & ASL	4;06	3;02	1	95
Nik	Deaf w/CI	English & ASL	5;0	3;08	2	100
Nik	Deaf w/CI	English & ASL	5;04	4;0	3	100
Nik	Deaf w/CI	English & ASL	5;10	4;06	4	100

### 3.3.3 Coding

See Section 2.3.3

### **3.3.4 Analyses**

See Section 2.3.4

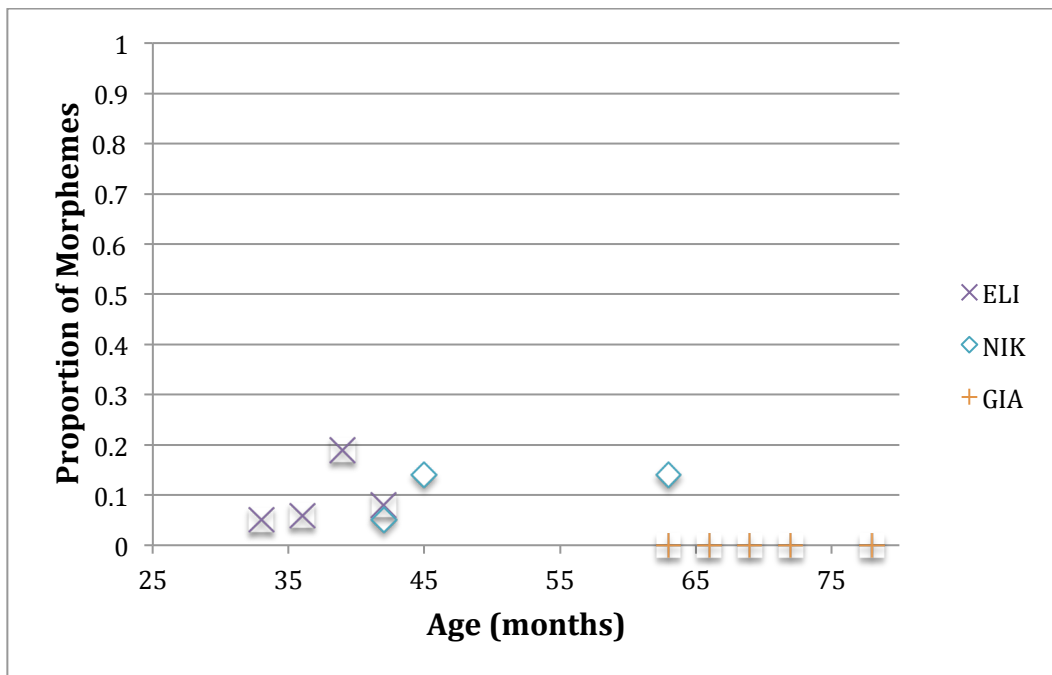
### **3.3.5 Reliability**

See Section 2.3.5

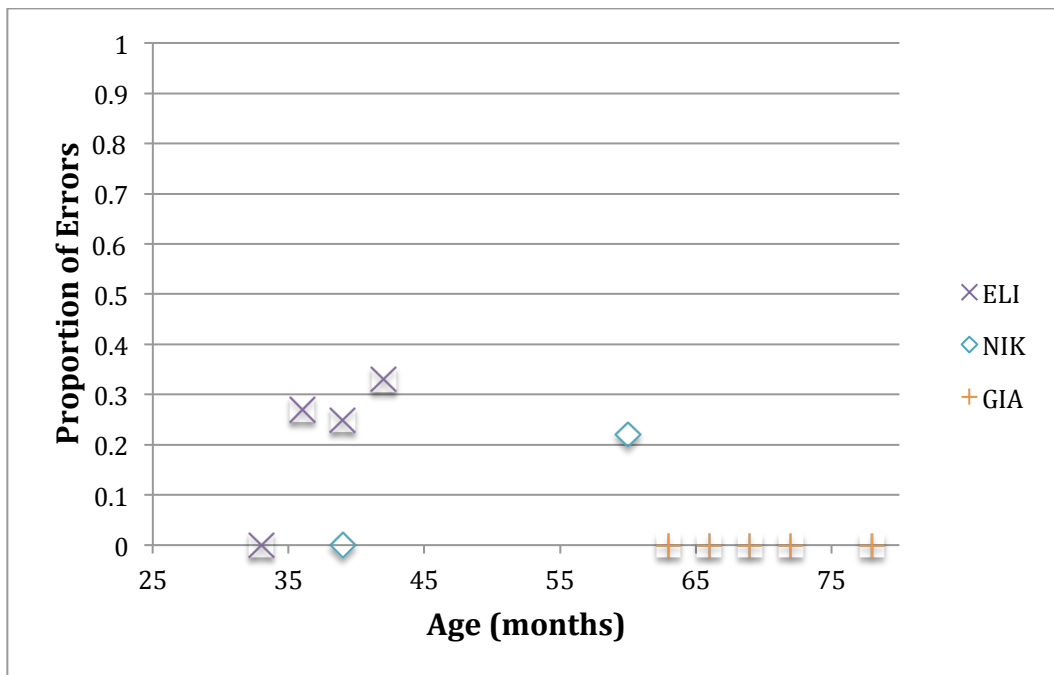
### 3.4 Results

#### 3.4.1 Modality

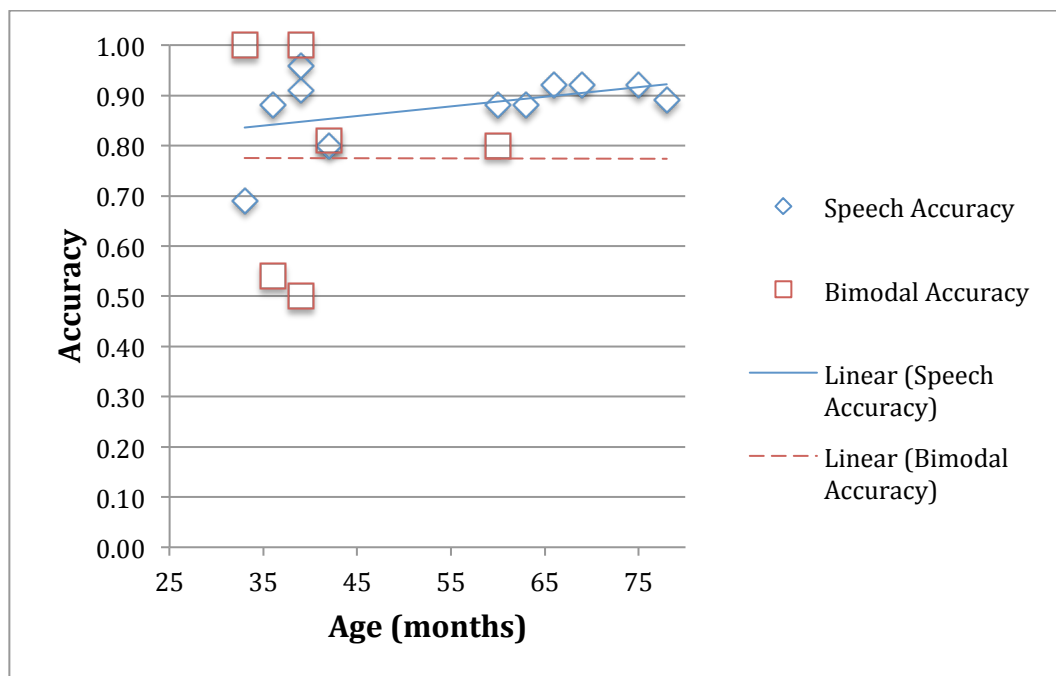
Eleven of the sixteen transcripts (68.75%) were coded for modality to see if the Deaf bimodal bilinguals exhibited a different pattern of language mixing and accuracy from the hearing bimodal bilinguals. The pattern was very similar to the hearing group. Figure 3.1 shows that most English morphemes were not produced in utterances that contained any amount of ASL, while Figure 3.2 shows that most errors with English morphology did not come from bimodal utterances. Just as in the hearing bimodal bilingual group, fewer bimodal utterances were produced as children aged (Figures 3.1 & 3.3). Accuracy with morphemes produced in speech increased across time (Figure 3.3), but there is no clear trend for the bimodal utterances. This is dissimilar to the hearing group, for which accuracy increased across time in both modalities. Overall, these results show that the morphological error patterns to be discussed below were not driven by language mixing.



**Figure 3.1: Deaf Bimodal Bilinguals' Proportion of Morphemes in Bimodal Modality**



**Figure 3.2: Deaf Bimodal Bilinguals' Proportion of All Errors Produced Bimodally**



**Figure 3.3: Deaf Bimodal Bilinguals' Accuracy by Utterance Type**

### 3.4.2 Mean Length of Utterance

As with the results from the hearing bimodal bilinguals and the literature on monolinguals, there is a general trend for MLU in both words (Figure 3.4) and morphemes (Figure 3.6) to increase with age. The rate at which this increase occurs varies from child to child. Figures 3.5 and 3.7 show that, for the most part, data from the Deaf bimodal bilinguals with CIs fits with the trend from the hearing bimodal bilinguals.



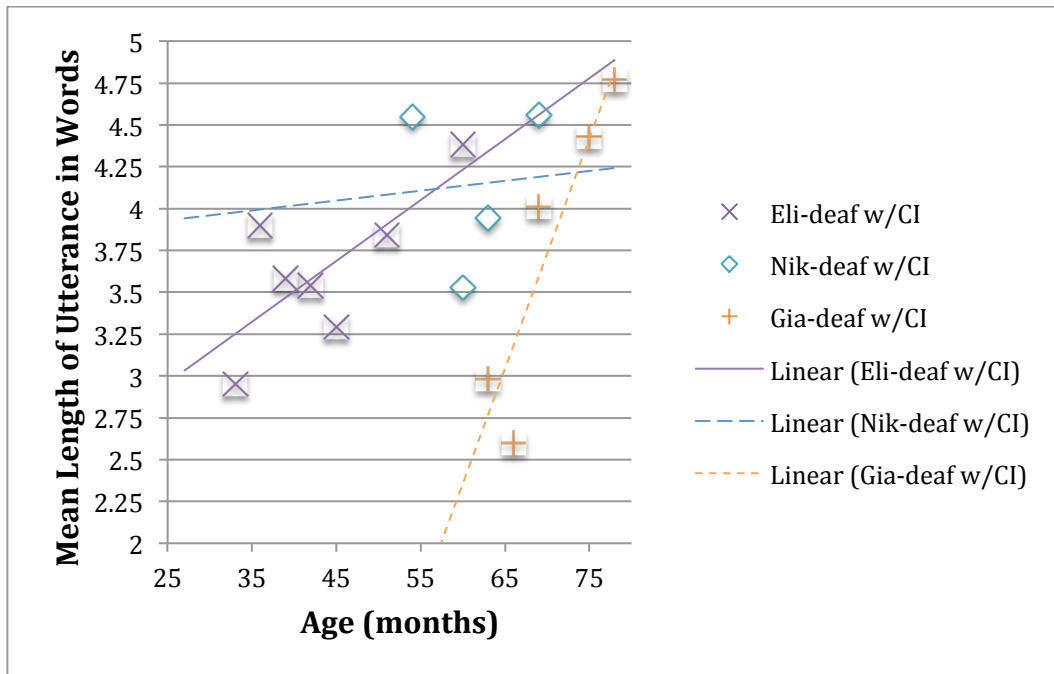


Figure 3.4: Deaf Bimodal Bilinguals' MLU<sub>w</sub> by Chronological Age

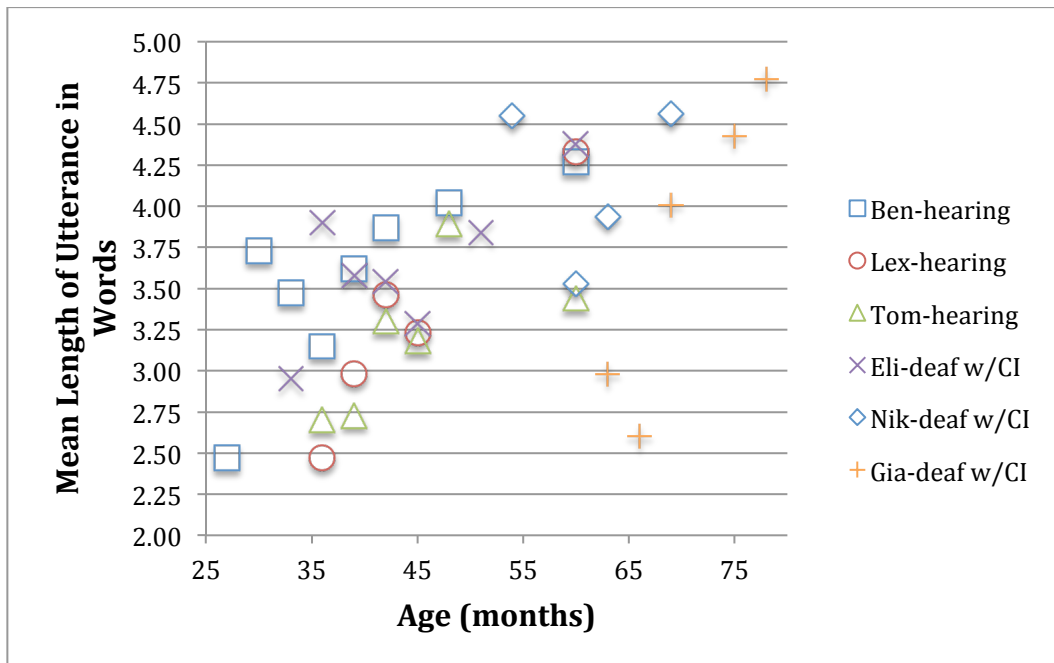


Figure 3.5: Deaf and Hearing Bimodal Bilinguals' MLU<sub>w</sub> by Chronological Age

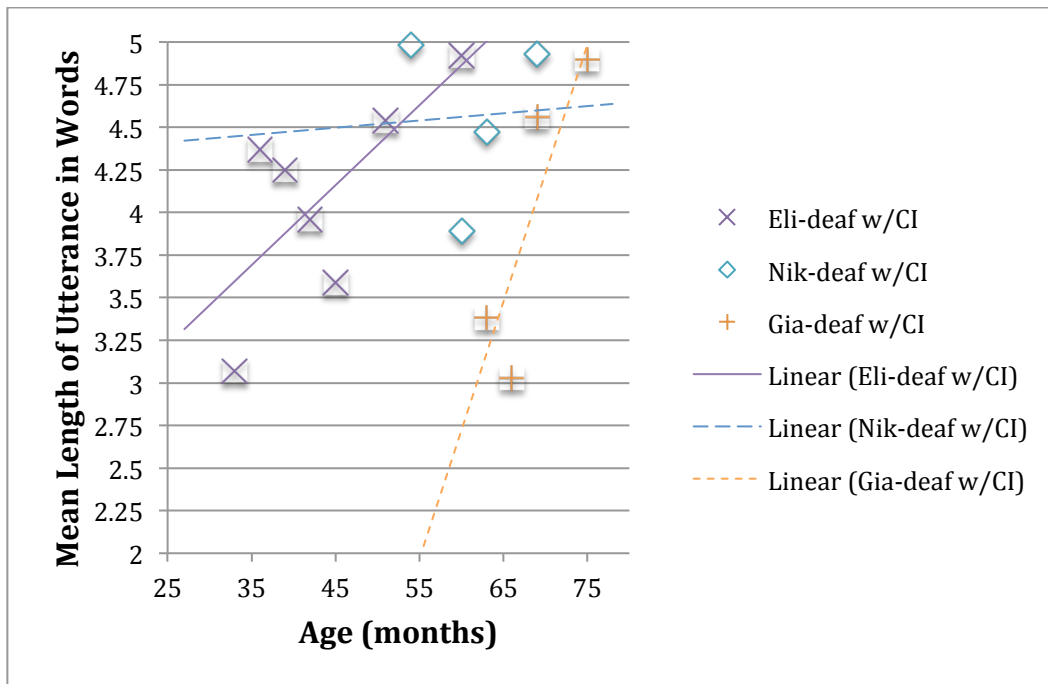


Figure 3.6: Deaf Bimodal Bilinguals' MLU<sub>m</sub> by Chronological Age

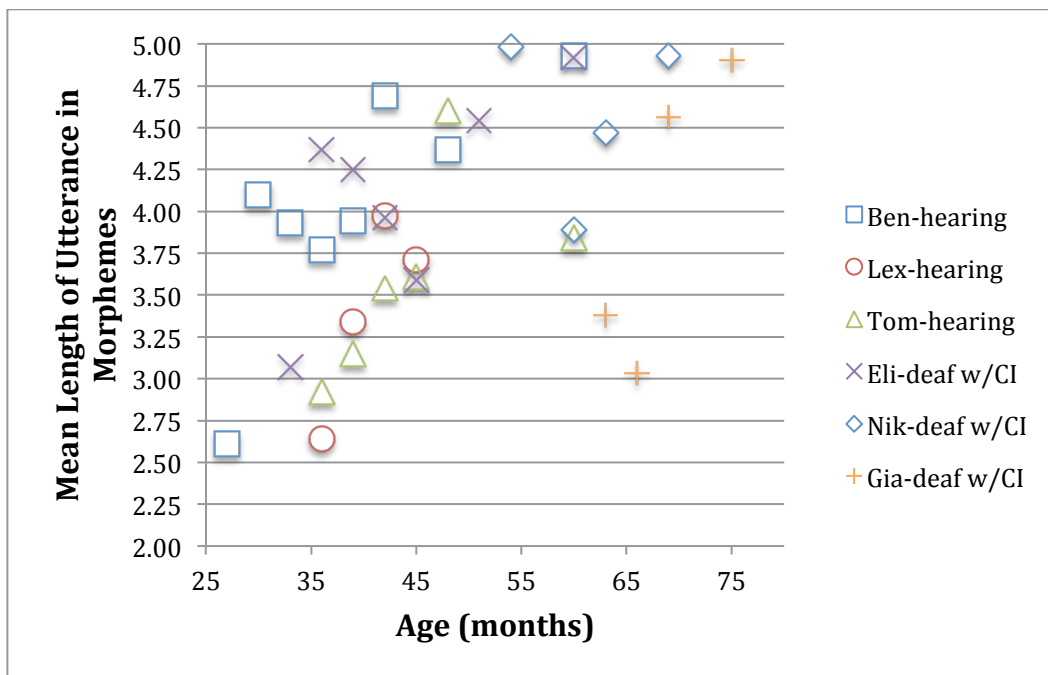
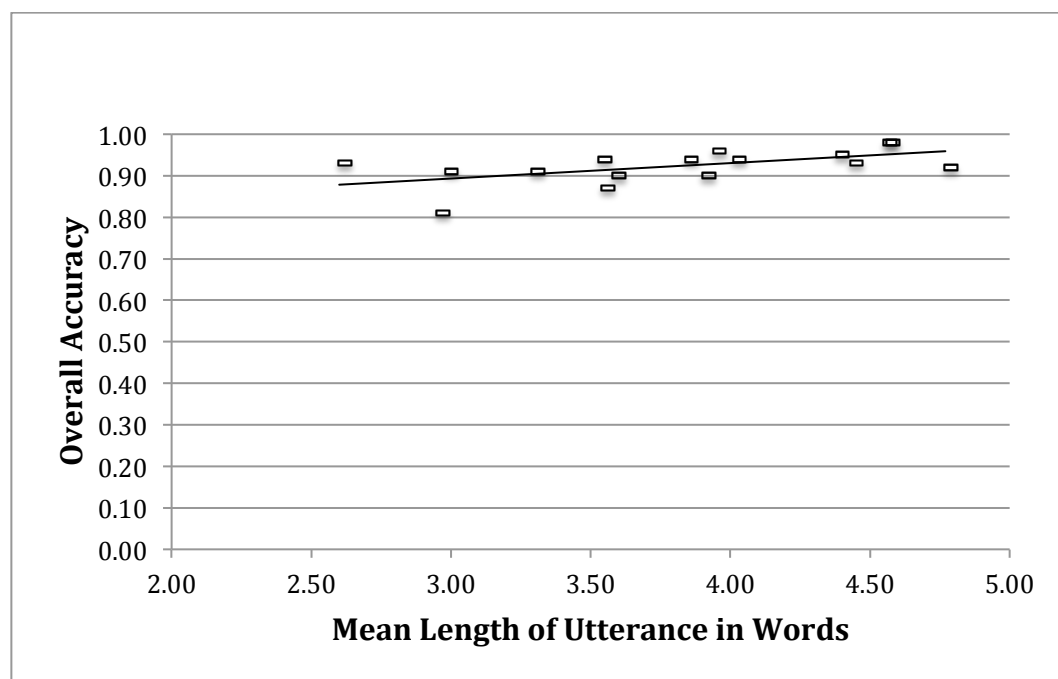


Figure 3.7: Deaf and Hearing Bimodal Bilinguals' MLU<sub>m</sub> by Chronological Age

Figure 3.8 shows the relationship between overall morphological accuracy rate and  $MLU_w$  for the Deaf bimodal bilinguals. Unlike the hearing bimodal bilinguals, accuracy rate increases only very slightly as  $MLU_w$  increases. This is likely due to the high accuracy rate even when the average length of utterances was short. It is important to point out that relatively old Deaf bimodal bilinguals produced these low  $MLU_w$  results. Generally these findings are consistent with those of Hammer et al. (2014), who found that some children with CIs produced short, but grammatically complex utterances.



**Figure 3.8: Deaf Bimodal Bilinguals' Overall Accuracy by  $MLU_w$**

Table 2.12 (repeated below as Table 3.4) and 3.5 allow comparison of the hearing bimodal bilinguals'  $MLU$  values to those of the Deaf bimodal bilinguals with CIs. Unfortunately, data was not collected from Gia and Nik at age three and Gia at age five. Table 20 provides Gia's  $MLU_w$  at age 5;03 for comparison. Eli and Nik have  $MLUs$  in the expected range for their age,

and only Gia shows any delay. Furthermore, as is apparent in Figures 3.4-3.7, Gia catches up to the group within six months time.

**Table 3.4: Hearing Bimodal Bilinguals' MLUw at 36 and 60 months**

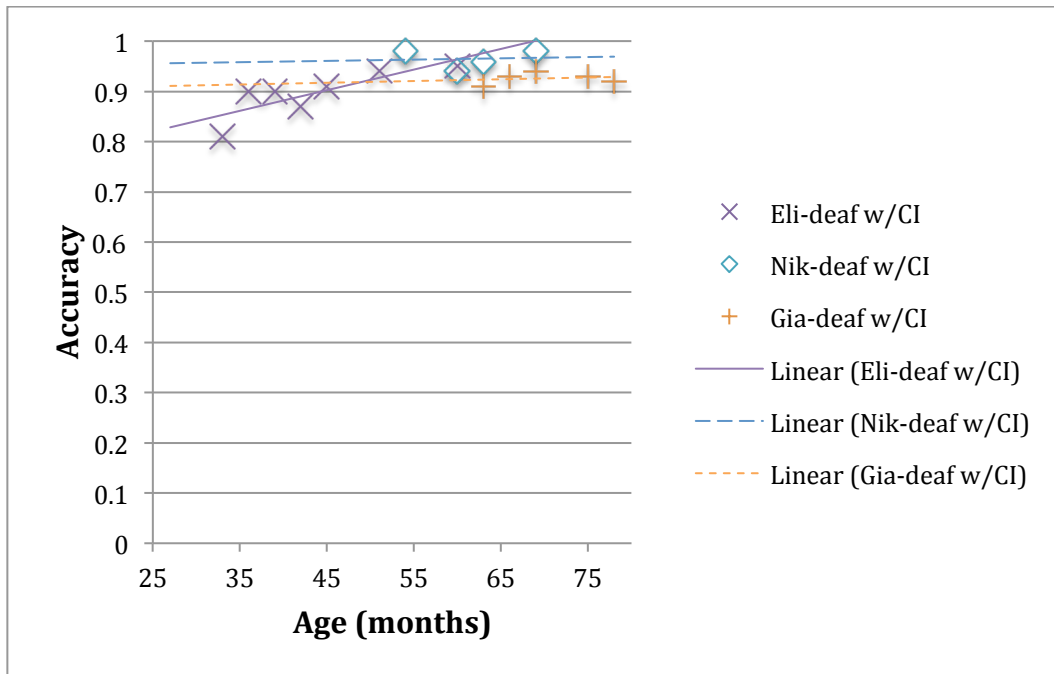
	<b>Ben</b>	<b>Lex</b>	<b>Tom</b>
<b>36 months</b>	3.15	2.47	2.70
<b>60 months</b>	4.27	4.33	3.44

**Table 3.5: Deaf Bimodal Bilinguals' MLUw at 36 and 60 months**

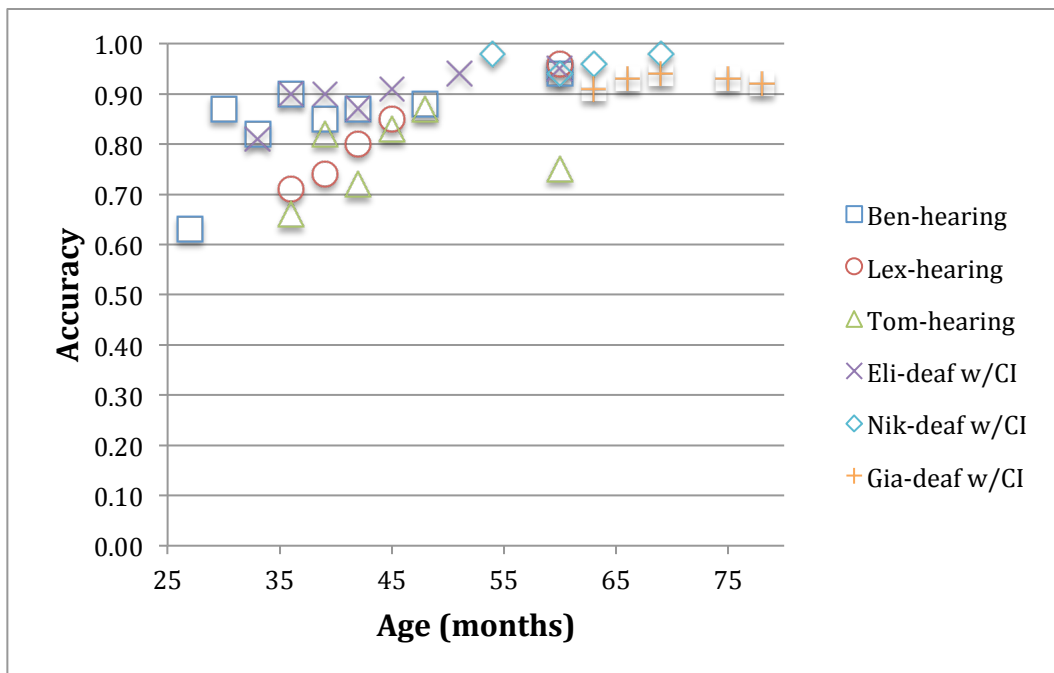
	<b>Eli</b>	<b>Gia</b>	<b>Nik</b>
<b>36 months</b>	3.90	-	-
<b>60 months</b>	4.38	2.98	3.53

### 3.4.3 Overall Accuracy

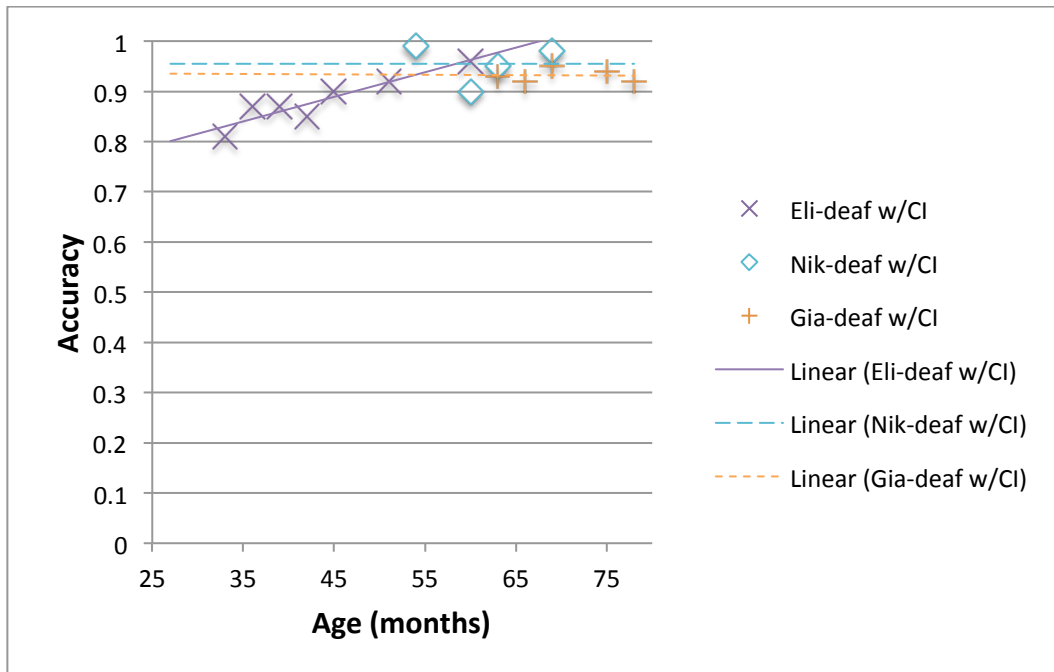
Figure 3.9 depicts the overall accuracy rates and includes errors of commission and pragmatic errors, as well as omission errors for the Deaf bimodal bilinguals. The linear trend lines show a very shallow slope of improvement, likely because these children have reached the performance ceiling. As Figure 3.10 shows, the results for the Deaf bimodal bilinguals fit with the trend for the hearing bimodal bilinguals data. All of Gia's and the latter half of Nik's data were collected at older ages than the hearing bimodal bilinguals. Although the accuracy rates at these older ages are high and similar to the last data points collected from the hearing group, it is unclear whether this group's performance also plateaus around this age. Figures 3.11-3.16 show similar results when accuracy is broken down into verb, plural and determiner.



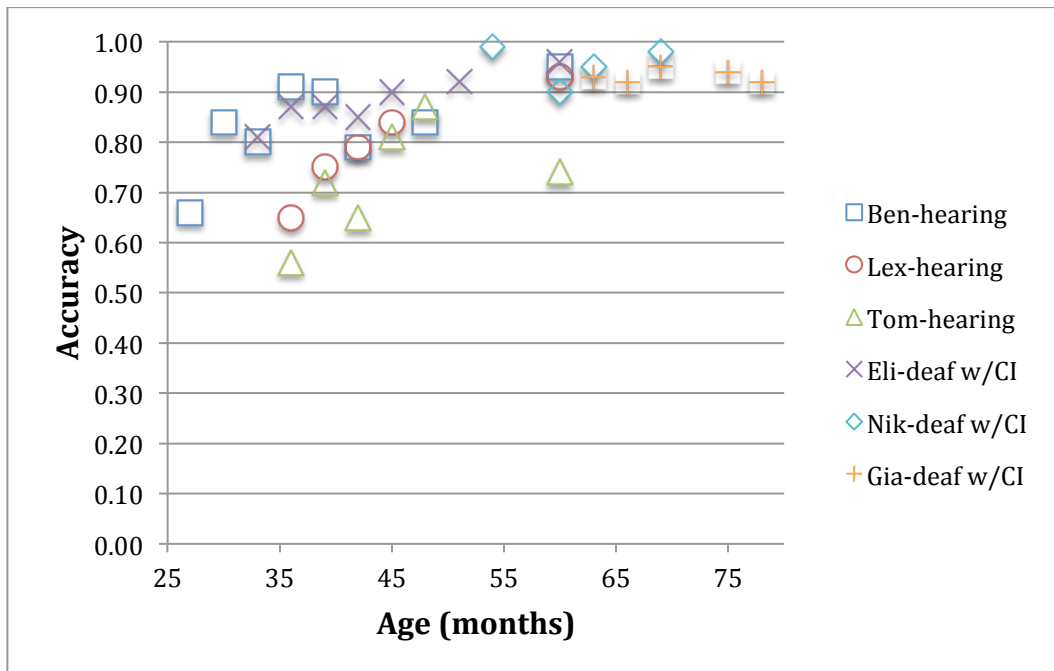
**Figure 3.9: Deaf Bimodal Bilinguals' Overall Accuracy by Chronological Age**



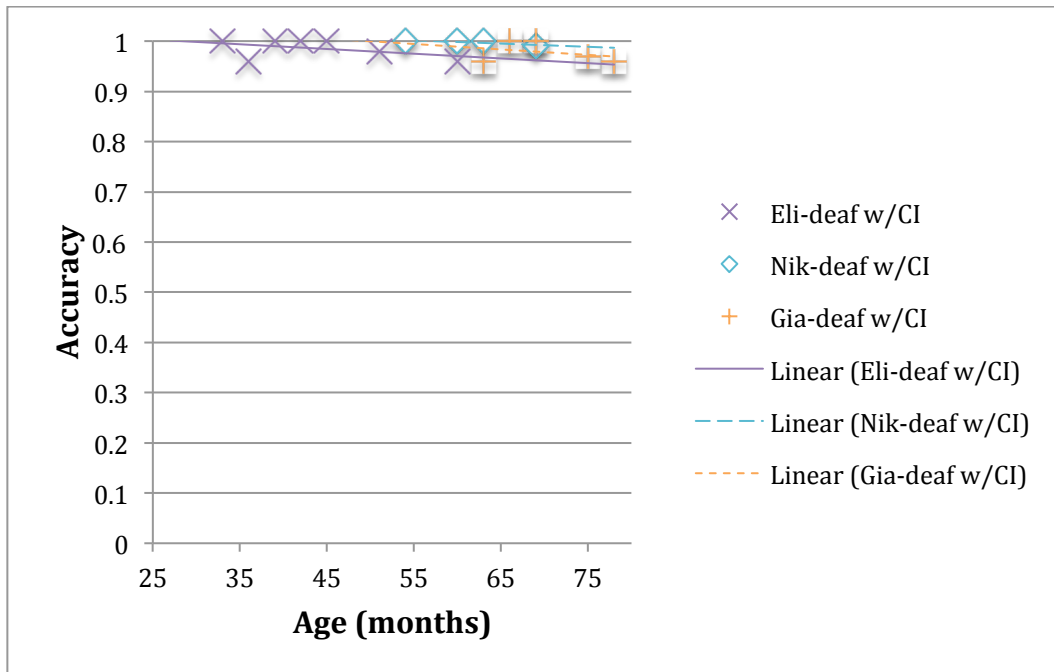
**Figure 3.10: Deaf and Hearing Bimodal Bilinguals' Overall Accuracy by Chronological Age**



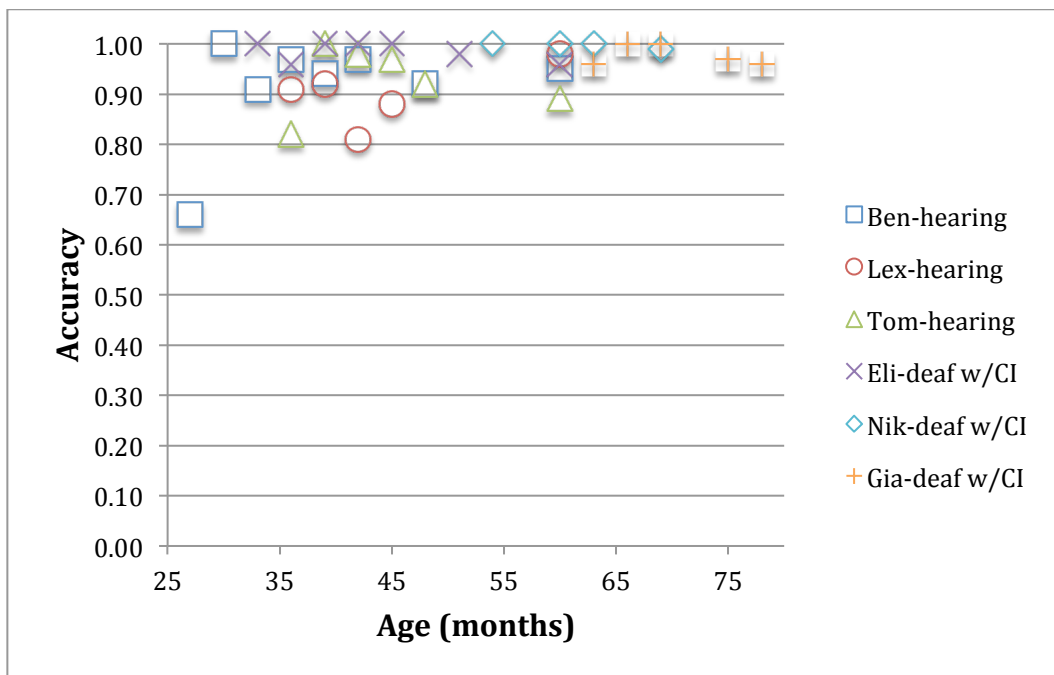
**Figure 3.11: Deaf Bimodal Bilinguals' Overall Verb Accuracy by Chronological Age**



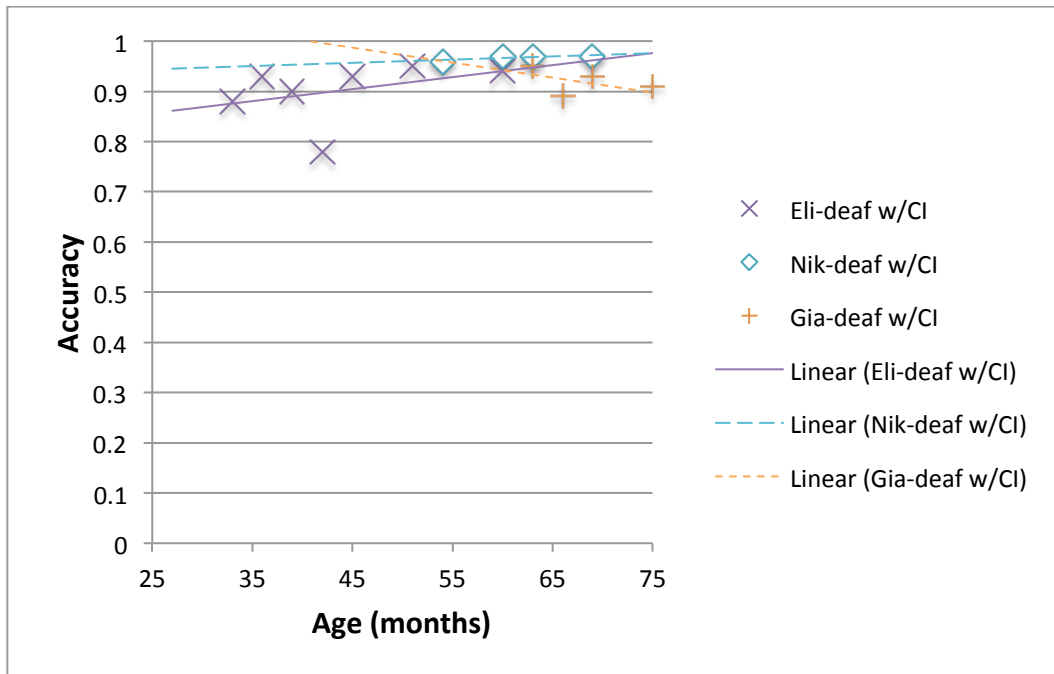
**Figure 3.12: Deaf and Hearing Bimodal Bilinguals' Overall Verb Accuracy by Chronological Age**



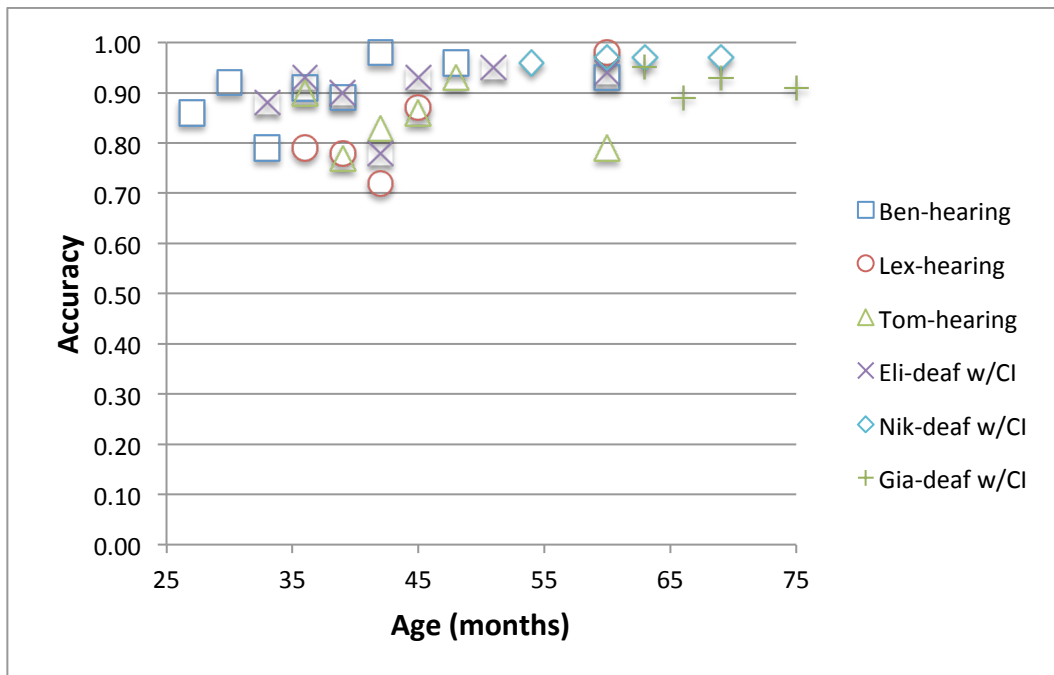
**Figure 3.13: Deaf Bimodal Bilinguals' Overall Plural Accuracy by Chronological Age**



**Figure 3.14: Deaf and Hearing Bimodal Bilinguals' Overall Plural Accuracy by Chronological Age**



**Figure 3.15: Deaf Bimodal Bilinguals' Overall Determiner Accuracy by Chronological Age**



**Figure 3.16: Deaf and Hearing Bimodal Bilinguals' Overall Determiner Accuracy by Chronological Age**



### 3.4.4 Individual Morpheme Performance

In this section, only the accuracy of morpheme use in obligatory contexts was considered, excluding the possibility of errors of commission and pragmatic errors. This was done in order to best compare with previous research. When the data was broken down into individual morphemes, many morphemes did not reach the minimum number of four obligatory contexts in numerous sessions. Figures 3.17-3.26 present the data for progressive *-ing*, regular plural, determiners, contractible copula and contractible auxiliary *be* for the Deaf bimodal bilinguals with CIs and their hearing bimodal bilingual peers. As the linear trend lines show, most children used most morphemes more accurately as they aged. Furthermore, the data from the Deaf bimodal bilinguals' with CIs seems to follow the overall trends of the hearing bimodal bilinguals.

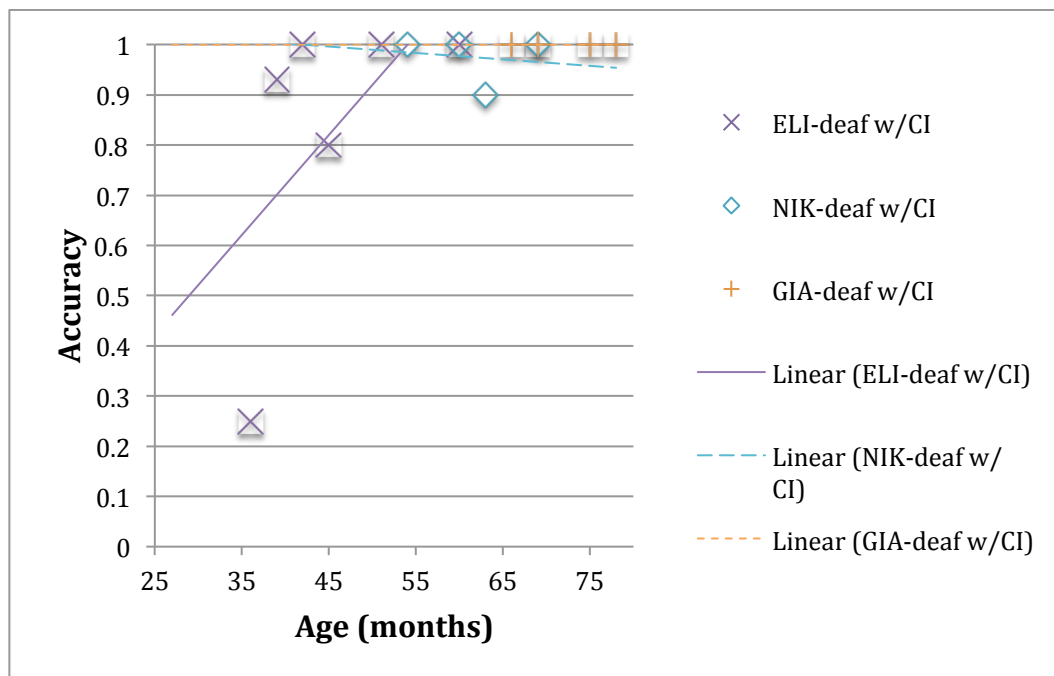
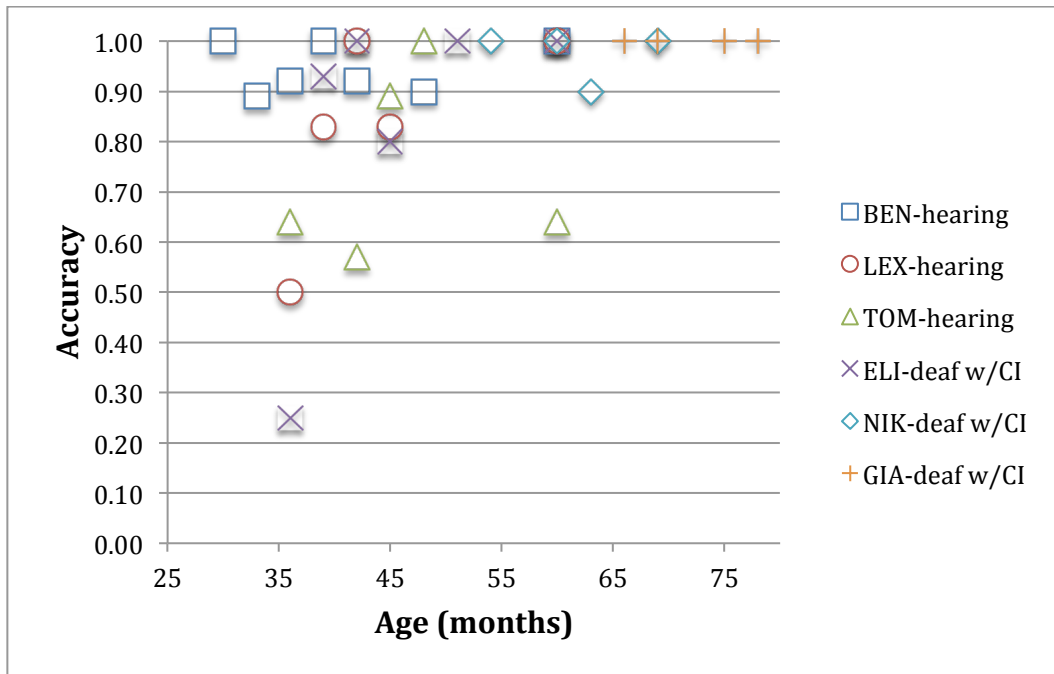
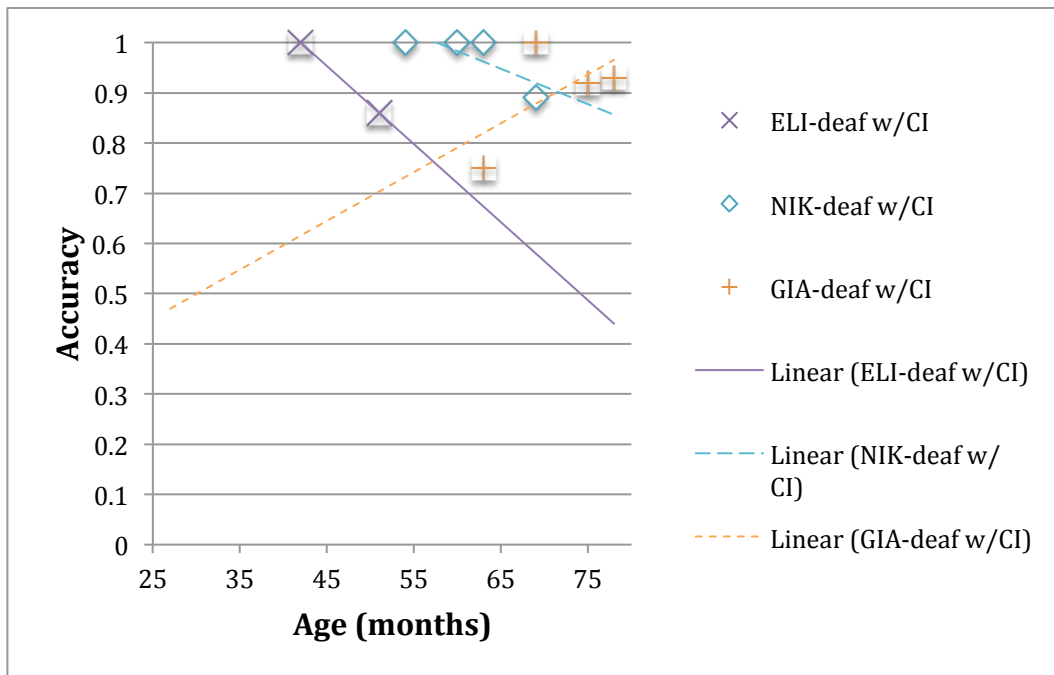


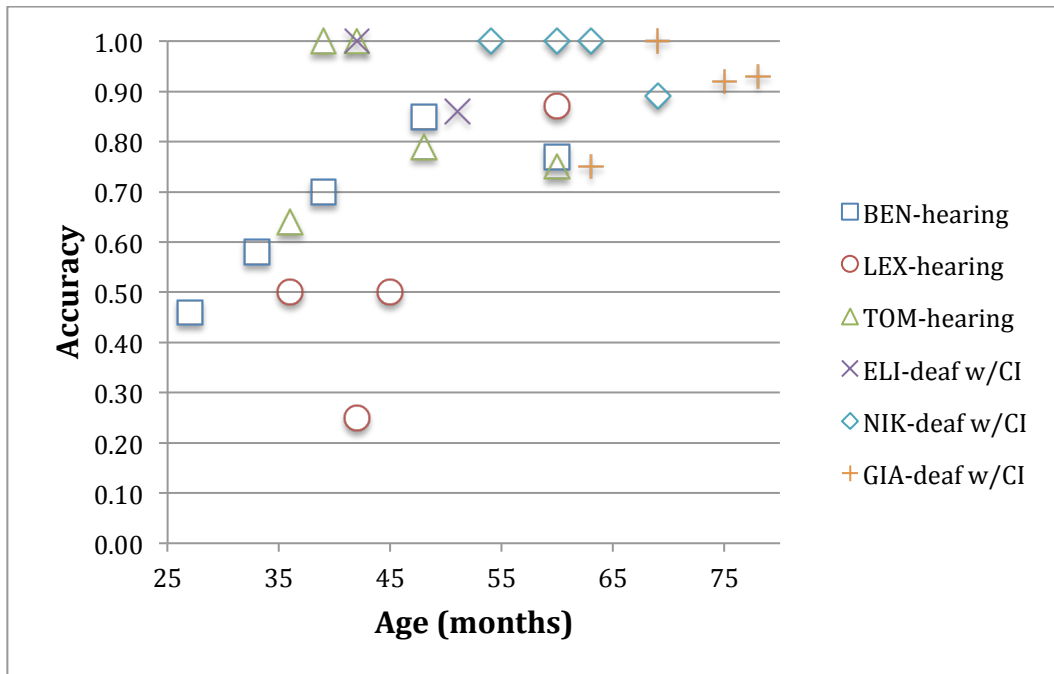
Figure 3.17: Deaf Bimodal Bilinguals' Accuracy with Progressive *-ing*



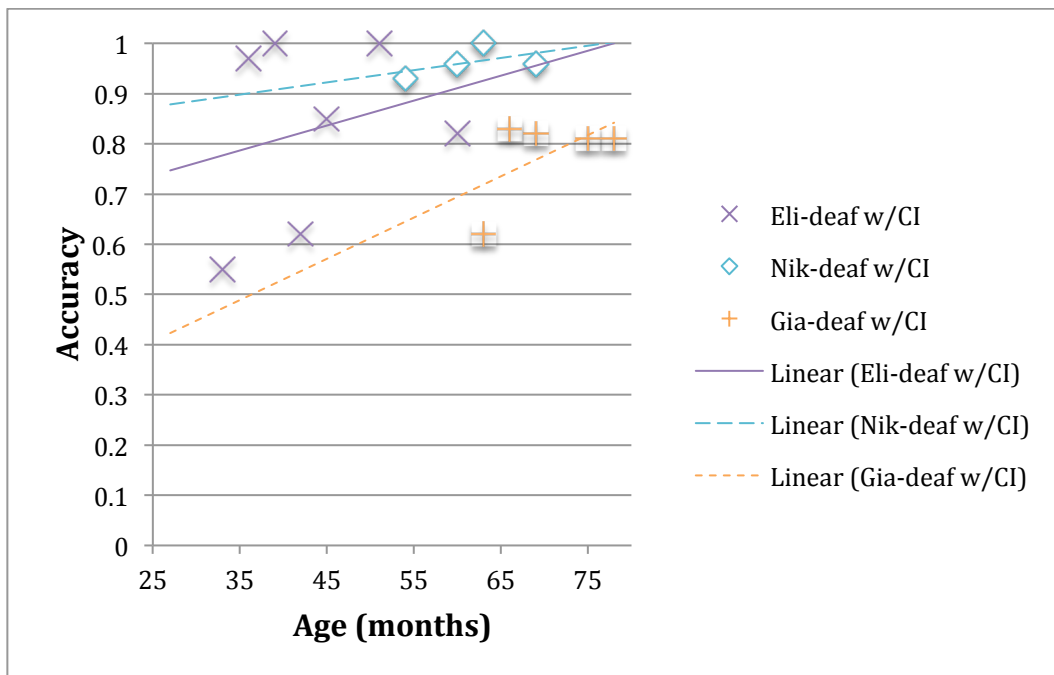
**Figure 3.18: Deaf and Hearing Bimodal Bilinguals' Accuracy with Progressive *-ing***



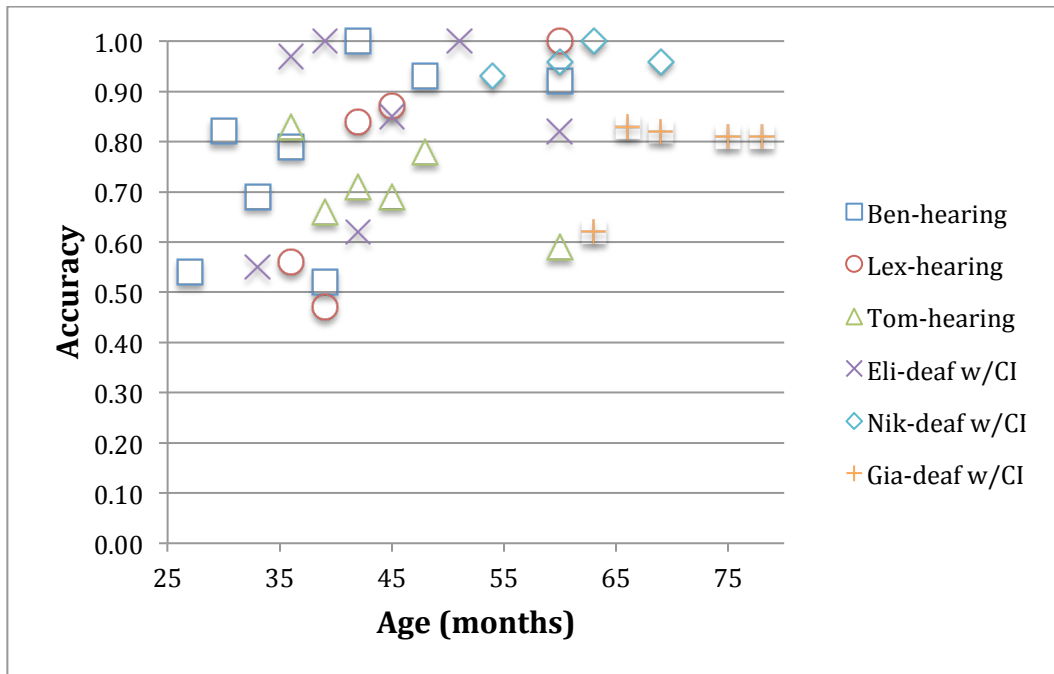
**Figure 3.19: Deaf Bimodal Bilinguals' Accuracy with Regular Plurals**



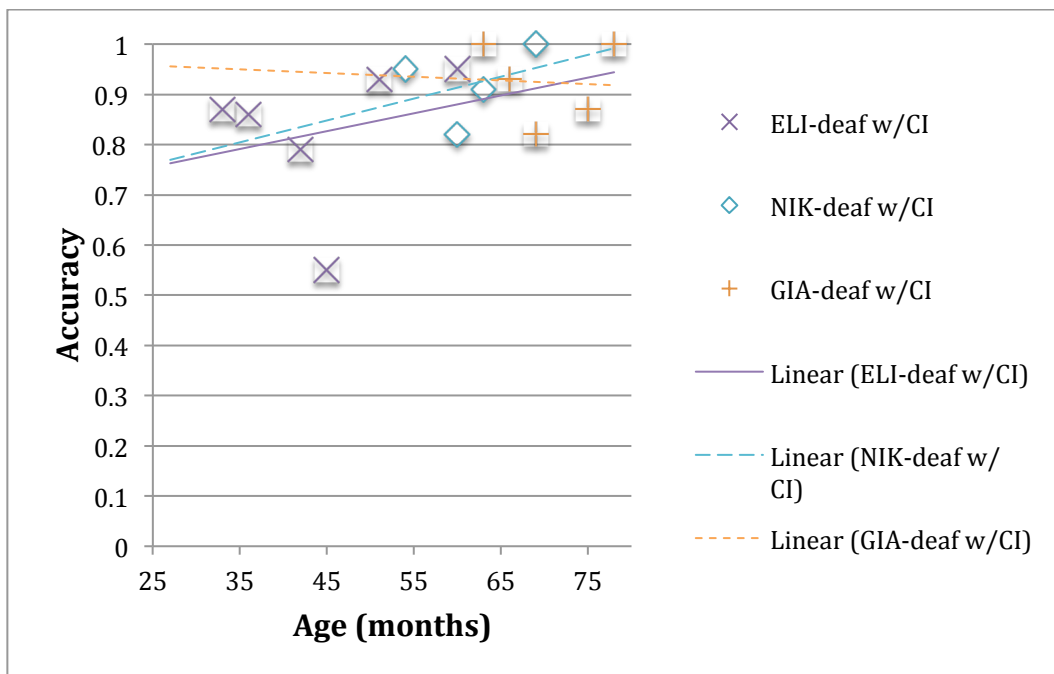
**Figure 3.20: Deaf and Hearing Bimodal Bilinguals' Accuracy with Regular Plurals**



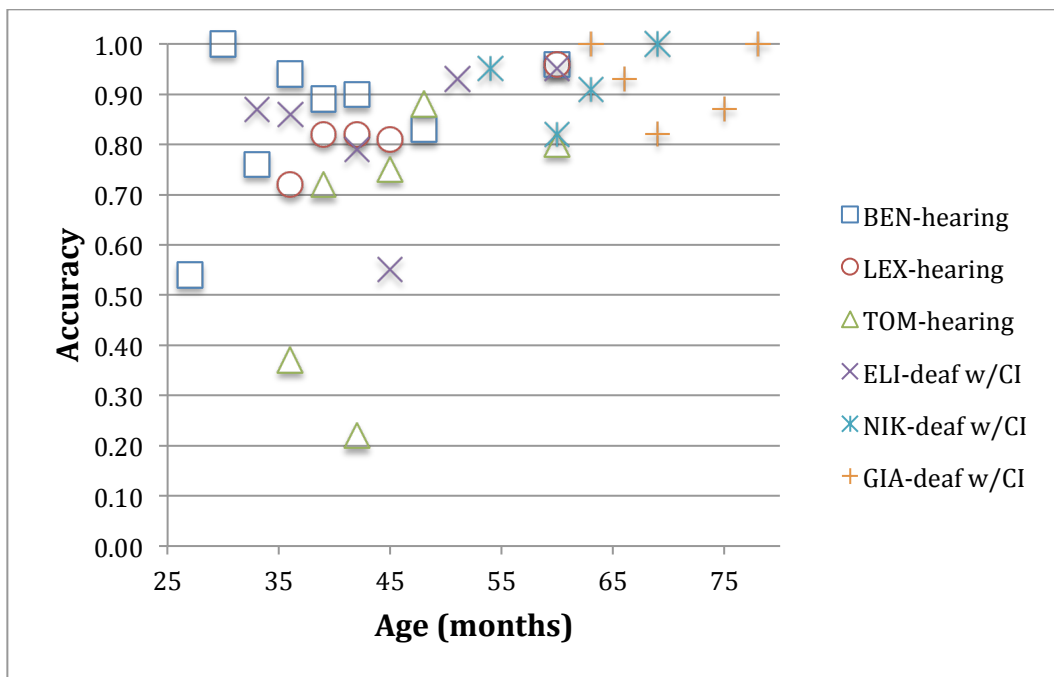
**Figure 3.21: Deaf Bimodal Bilinguals' Accuracy with Determiners**



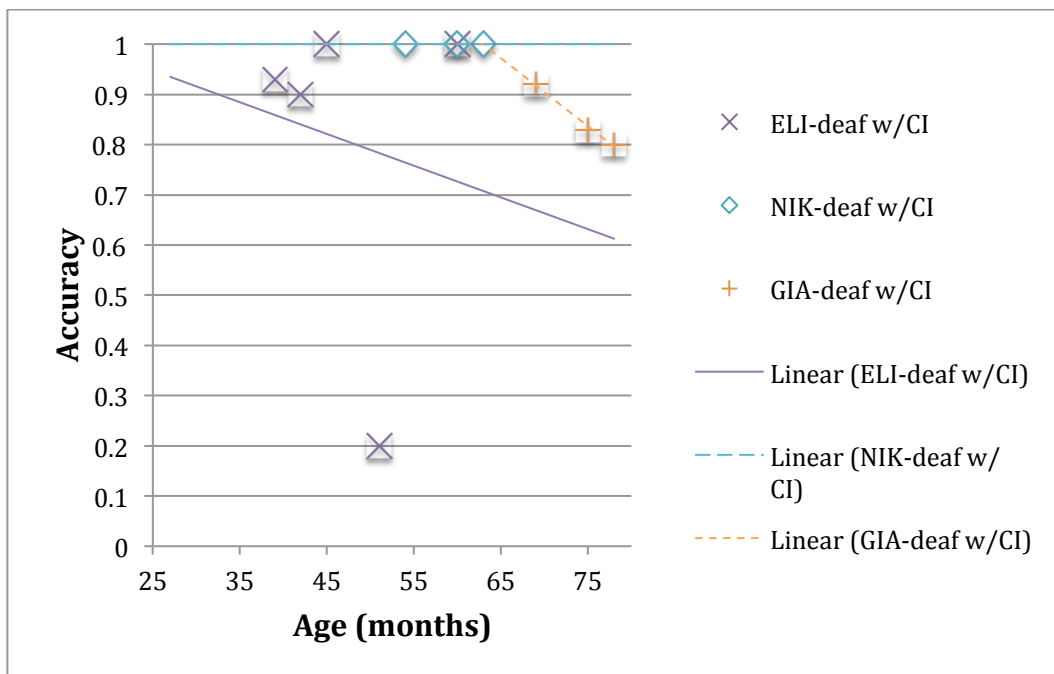
**Figure 3.22: Deaf and Hearing Bimodal Bilinguals' Accuracy with Determiners**



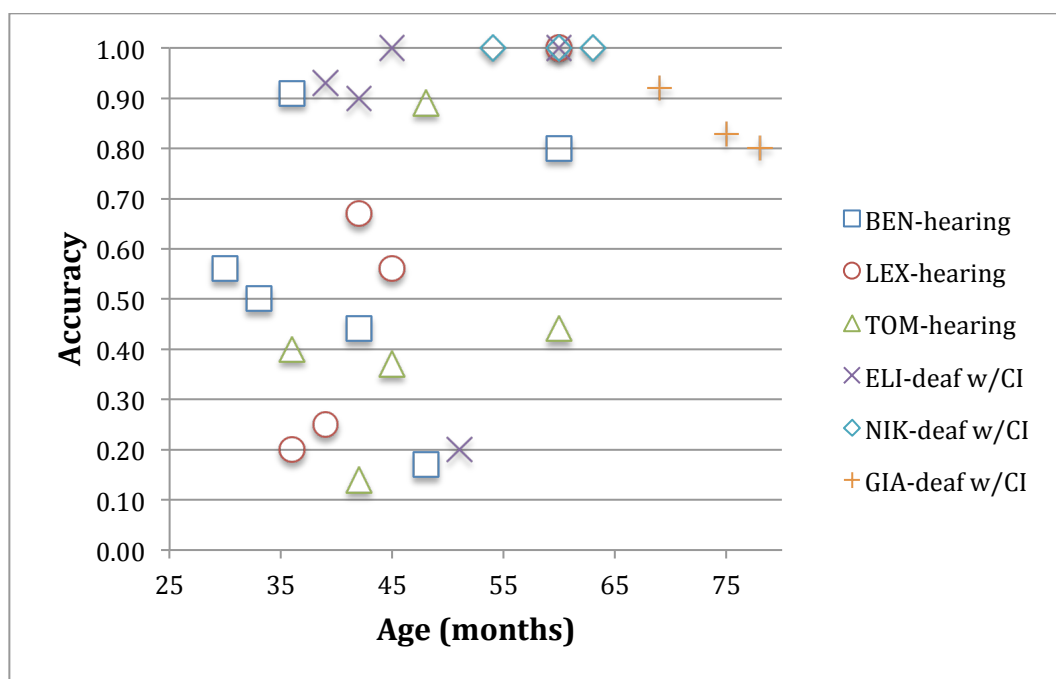
**Figure 3.23: Deaf Bimodal Bilinguals' Accuracy with Contractible Copulas**



**Figure 3.24: Deaf and Hearing Bimodal Bilinguals' Accuracy with Contractible Copulas**



**Figure 3.25: Deaf Bimodal Bilinguals' Accuracy with Contractible Auxiliaries**



**Figure 3.26: Deaf and Hearing Bimodal Bilinguals' Accuracy with Contractible Auxiliaries**

Using the same criterion for acquisition as in the previous chapter (90% accuracy in one transcript), the age of acquisition for individual morphemes with sufficient obligatory contexts is provided in Table 3.6. The number in parentheses is the hearing age (in months) that corresponds to each chronological age. This can be compared with the results from the hearing bimodal bilinguals in Table 2.13, repeated below as Table 3.7. It is important to note that the data from Gia and Nik was collected starting at ages 54 (4;06) and 63 months (5;03), respectively. Therefore, it was not possible to establish earlier ages of acquisition than this for these participants. Furthermore, Gia's data was only analyzed until the chronological age of 78 months (6;06), so it was not possible to determine an age of acquisition for determiners/articles past this point.

**Table 3.6: Deaf Bimodal Bilinguals' Age of Acquisition of Grammatical Morphemes**

<b>Morpheme</b>	<b>Eli</b>	<b>Gia</b>	<b>Nik</b>
progressive <i>-ing</i>	39 (27)	66 (48)	54 (39)
plural	42 (30)	69 (51)	54 (39)
articles <i>a(n)/the</i>	36 (24)	did not reach criterion	54 (39)
contractible copula	51 (39)	63 (45)	54 (39)
contractible auxiliary	39 (27)	69 (51)	54 (39)

**Table 3.7: Hearing Bimodal Bilinguals' Age of Acquisition of Grammatical Morphemes**

<b>Morpheme</b>	<b>Ben</b>	<b>Lex</b>	<b>Tom</b>
progressive <i>-ing</i>	36	42	48
plural	did not reach criterion	did not reach criterion	39
articles <i>a(n)/the</i>	42	60	did not reach criterion
contractible copula	36	60	did not reach criterion
contractible auxiliary	36	60	did not reach criterion

There is no evidence that the Deaf bimodal bilinguals with CIs acquired any morphemes later than the hearing bimodal bilingual group. Eli achieved mastery for all morphemes in the first transcript available. For the progressive morpheme, Eli's age of acquisition is well within the range of the three hearing participants and Gia and Nik had acquired this morpheme by the

first transcript available for consideration (there were not enough obligatory contexts for the progressive morpheme in Gia's first transcript, so age 66 months (5;06) was her earliest possible age of acquisition. Results also look similar between the two groups for the plural morpheme because two of the three hearing bimodal bilingual participants had not reached criterion by 60 months (5;00). Articles were a possible problem area for the hearing bimodal bilinguals, yet only Gia has a clear delay for this morpheme. Ages of acquisition for the contractible copula and auxiliary are also similar between the two groups.

Table 2.2 is repeated below (as Table 3.8) to provide the monolingual data as comparisons. While there is no evidence that the Deaf bimodal bilinguals are behind the hearing bimodal bilinguals, Table 3.6 highlights possible deficits when comparing to hearing monolingual English children. Nik had already acquired all of these morphemes by the first transcript available, so although this age is quite old for acquisition, there is no evidence he acquired these morphemes later than monolinguals. Eli's acquisition of the plural morpheme is significantly behind, although when his hearing age is considered, it is quite similar to the age at which monolinguals master the plural. Gia shows a deficit for the progressive, plural and articles. Comparing based on hearing age does not make these results look more similar to the monolinguals.

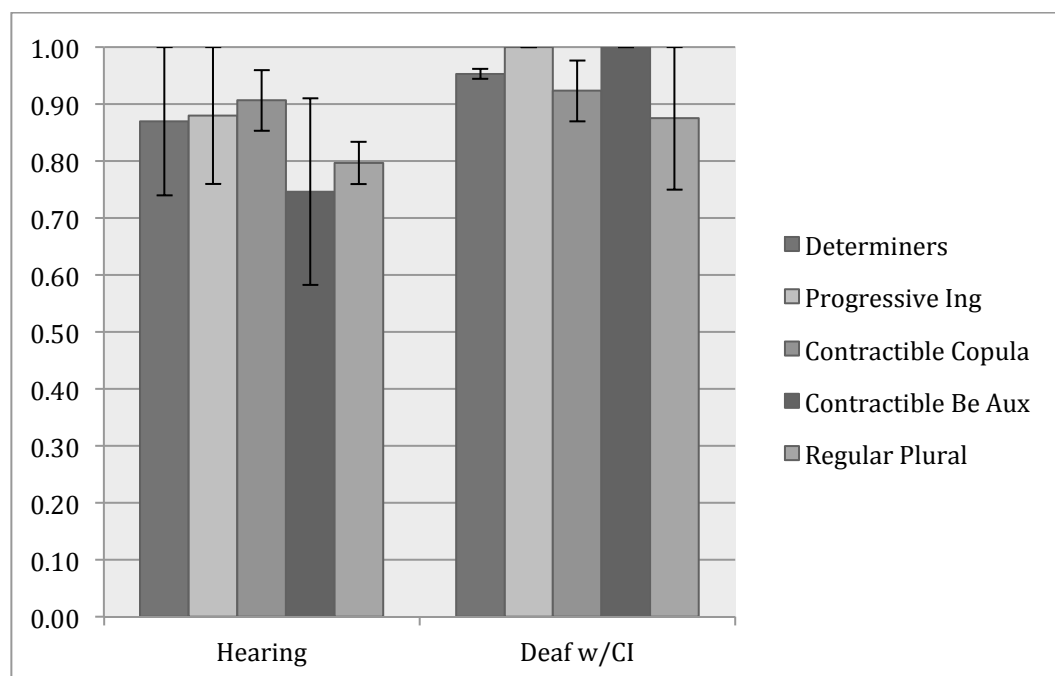


**Table 3.8: Monolinguals' Age of Acquisition of Grammatical Morphemes**

<b>Morpheme</b>	<b>Lahey et al.</b>	<b>Adam</b>	<b>Sarah</b>	<b>Eve</b>
<b>progressive - ing</b>	35	30	34	21
<b>plural</b>	29	30	34	23
<b>articles a(n)/the</b>	N/A	38	37	<i>did not reach criterion</i>
<b>contractible copula</b>	35	<i>did not reach criterion</i>	<i>did not reach criterion</i>	<i>did not reach criterion</i>
<b>contractible auxiliary</b>	<i>did not reach criterion</i>	<i>did not reach criterion</i>	<i>did not reach criterion</i>	<i>did not reach criterion</i>

### 3.4.5 Perceptual Salience Hypothesis

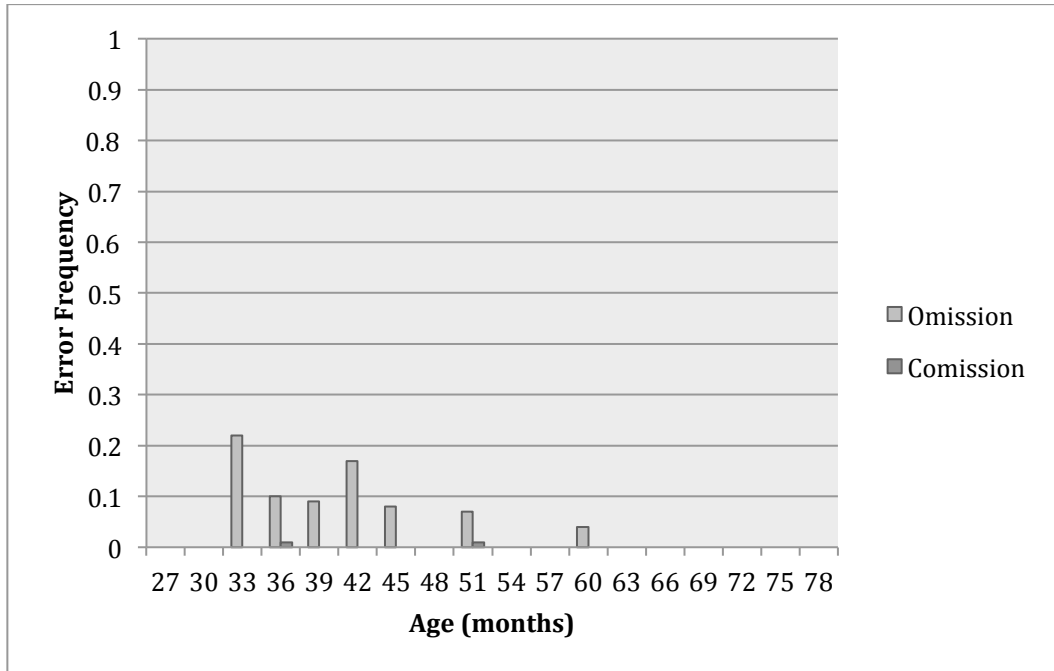
The predictions of the perceptual salience hypothesis were considered at age 5;00 (60 months) because data was available from all subjects at this point. Gia's data is drawn from age 5;03 (63 months) because this was the earliest time point available. Average accuracy on each morpheme is presented in Figure 3.27, with the morphemes in order of decreasing saliency (left to right). As can be seen in this figure, there is no obvious support for the perceptual salience hypothesis in either group at this age. This could be partially due to the large variation across subjects, as evidenced by the large error bars.



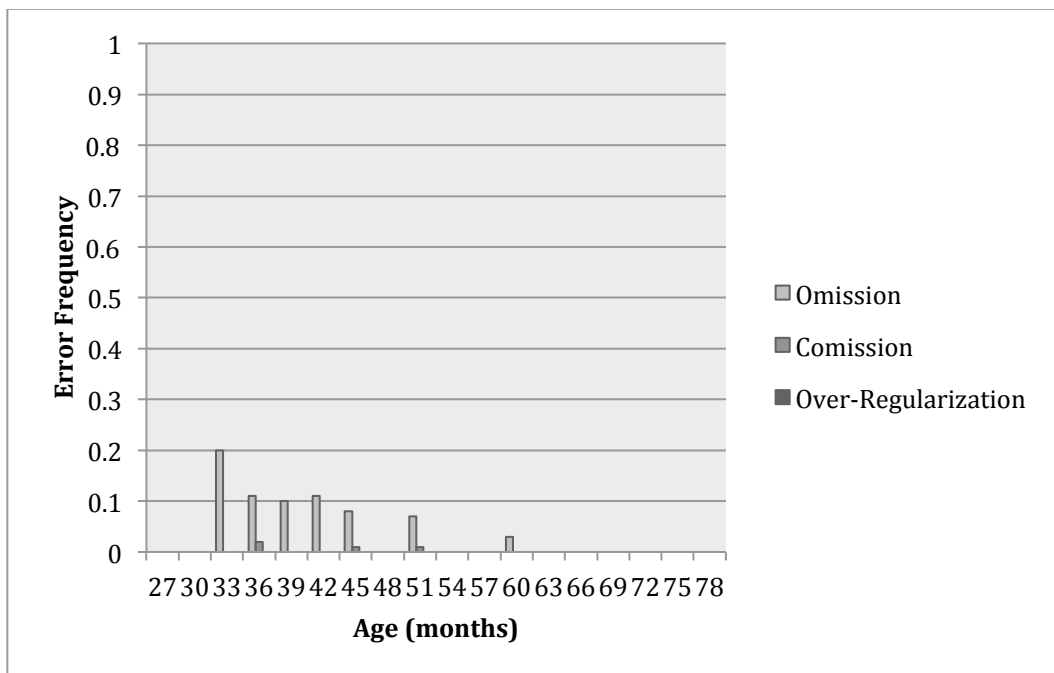
**Figure 3.27: Bimodal Bilinguals' Accuracy by Morpheme in Order of Perceptual Salience at Age 5**

### 3.4.6 Error Type Frequencies

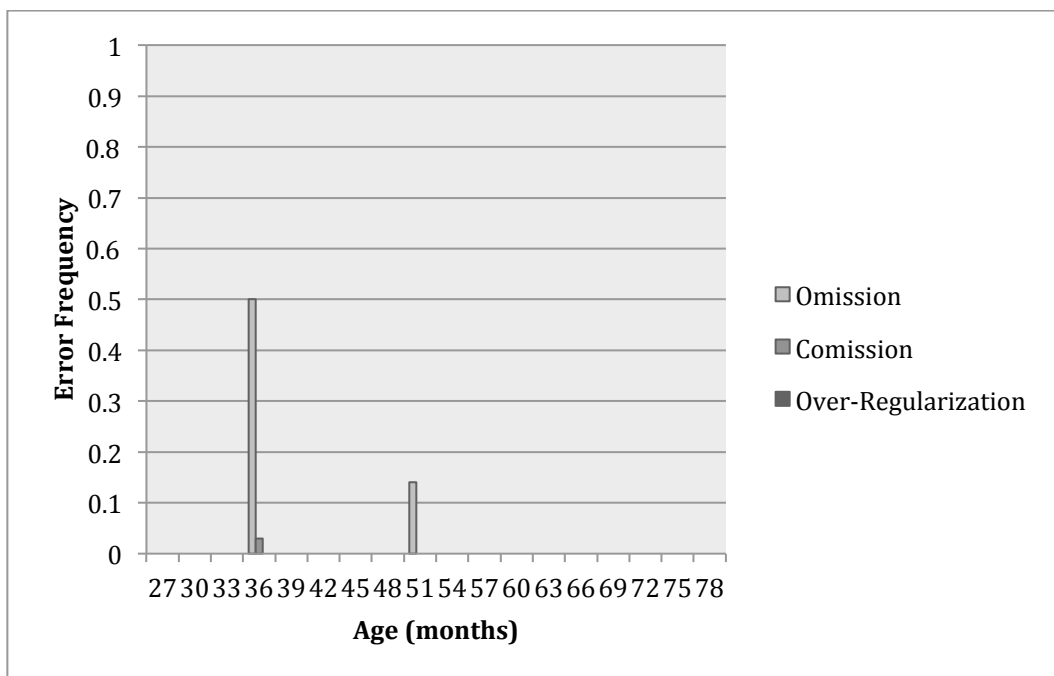
Because Eli's morphological development was analyzed at more ages than the other two participants, his error frequency graphs are provided in Figures 3.28-3.31 below to illustrate the overall error pattern for the Deaf bimodal bilinguals with CIs. The error patterns were similar for the other two participants, as can be seen in the graphs provided in Appendix C. As with the hearing bimodal bilinguals (and hearing monolinguals), the Deaf bimodal bilinguals predominately made errors of omission. At no age did Eli make errors of over-regularization with past tense or plural markers, which is unlike the hearing bimodal bilinguals and hearing monolinguals. There was evidence of over-regularization errors in Nik and Gia for past tense, but not plural. This could be due to the limited use of irregular nouns in the longitudinal language samples, which provided few opportunities for over-regularization of the plural marker.



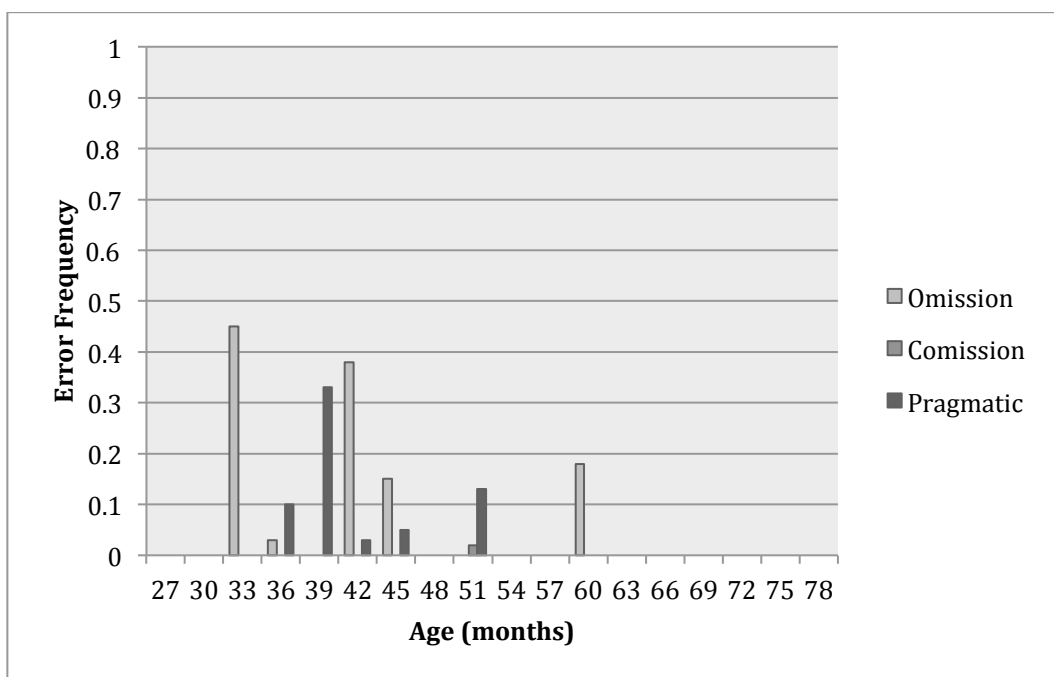
**Figure 3.28: Eli's Overall Error Type Frequencies**



**Figure 3.29: Eli's Overall Verb Error Type Frequencies**



**Figure 3.30: Eli's Overall Plural Error Type Frequencies**



**Figure 3.31: Eli's Overall Determiner Error Type Frequencies**

### 3.5 Discussion

Overall, the results from the Deaf bimodal bilinguals with CIs were strikingly similar to those of the hearing bimodal bilinguals. They used similarly low amounts of code-blending/switching (i.e., utterance that contained both ASL and English), with the rate of these productions decreasing as the children got older. This could be due to greater sensitivity to the language of the interlocutor (English speaking researchers), as well as growing proficiency with and dominance in English. The vast majority of morphological errors produced by these children were within monolingual English utterances, suggesting these mistakes were not caused by the effort involved in producing both languages simultaneously. Conversely, this does not necessarily mean that bilingualism in general did not influence morphological development in the participants.

MLU was generally within the expected range, or reached this range soon after data collection began. Overall error rates were also very similar, although it is not clear how hearing bimodal bilinguals are expected to perform after age 5;00 (60 months), an age range in which much of the data from Gia and Nik was drawn. While the Deaf bimodal bilinguals do not perform worse at these ages than the hearing group at 5;00, they do seem to plateau around 90-95% accuracy. Future research should consider older age ranges for hearing bimodal bilinguals to establish the pattern of morphological development after the age of 5;00. Rarely do studies of monolinguals consider children's morphological development after age 5;00 or reaching 90% accuracy, so it is difficult to make a comparison to previous literature on monolinguals.

Unlike the hearing bimodal bilinguals, there is no clear relationship between MLU in words and overall morphological accuracy. This is despite the fact that the data from both groups cover a similar MLU range (2.5-5.0). Although the Deaf bimodal bilinguals are producing

shorter utterances at earlier sessions, their morphological accuracy is not correspondingly lower. This shows that, at least for this group, MLU is not a good predictor of morphological accuracy and may not be a good way to match groups of Deaf bimodal bilinguals with CIs to hearing peers at similar stages of grammatical development.

When accuracy with individual morphemes was considered, the two groups again looked comparable. Although there is no evidence that the Deaf bimodal bilinguals acquired any of the six morphemes (progressive, plural, determiner, contractible copula, contractible auxiliary) later than the hearing bimodal bilinguals, this group may still have problems with other grammatical morphemes that were too infrequent in our samples to test (such as regular past tense). When comparing to the monolingual group, the same morphemes were vulnerable to deficits as in the hearing bimodal bilinguals, namely progressive *-ing*, regular plural *-s* and the definite and indefinite articles *the* and *a(n)*. The pattern of performance across morphemes did not support the perceptual salience hypothesis in either group, but wide variation was observed across children and more participants would likely be necessary for such an effect to be observable.

Finally, overall error type frequency patterns were similar in both groups. Omission errors are the most common error type in Deaf bimodal bilinguals with CIs, hearing bimodal bilinguals and, of course, monolingual children. The Deaf bimodal bilinguals did not produce many over-regularization errors, but neither did the hearing bimodal bilinguals. Given the few obligatory contexts for irregular noun plurals or past tense verbs, it is impossible to tell whether the Deaf group exhibits an abnormal pattern in the acquisition of irregular morphological forms.

These results suggest that the Deaf bimodal bilinguals with CIs have an advantage that most other children with CIs do not have: natural language exposure from birth in the form of sign language. This is not to say that these children performed as well as expected based on

monolingual results. In fact, they exhibit morphological deficits similar to hearing bimodal bilinguals acquiring the same language pair. Therefore, these deficits are likely due to bilingualism effects rather than any complications of delayed exposure to spoken language or hearing through a cochlear implant. However, the sample size of three children with relatively high SES may not be representative of all children with cochlear implants. Moreover, most deaf children are born to hearing, non-signing parents, and it is not clear to what extent input from non-native signing parents might have a similar effect on spoken English development.

## **Chapter 4: Elicitation Data**

In this chapter, data from elicited speech samples is discussed. Section 4.1 motivates the inclusion of such data, while Section 4.2 discusses the predicted results. Section 4.3 describes the participants and explains the method of data collection and analysis. Sections 4.4 and 4.5 present and discuss the results.

### **4.1 Background**

This elicitation study serves three major purposes: it uses (1) a different methodology to evaluate grammatical morpheme use in (2) a greater number of children at (3) older ages. The first point is important because many of the previous studies of grammatical morpheme development in bilinguals and children with CIs have used an elicitation task (e.g., the TEGI) rather than spontaneous language samples. It is reasonable to expect performance to vary depending on the task type because, during spontaneous speech, a child can avoid using structures that she is not comfortable with, while in an elicitation task, a child may be forced to use these structures (e.g., Snyder, 2007).

Although both of the populations of interest to this study (hearing bimodal bilinguals and Deaf bimodal bilinguals with CIs) are relatively small, it is important to include as many children as possible because of the wide variation seen within normal child language development (e.g., Lahey et al., 1992). This problem is exacerbated in the CI group because numerous researchers have found even greater variation in language outcomes among children with CIs (e.g., Duchesne, Sutton & Bergeron, 2009; Szagun & Stumper, 2012). Finally, the fact that the child participants are overall older than in the longitudinal study gives a sense of how grammatical



morpheme development continues in these children, beyond the age range that is typically of interest to research on morpheme acquisition. This is especially important for this study of morphological development in children with cochlear implants because it is unclear whether their performance at ages five and six should be considered typical, as discussed in Section 3.5 above.

## **4.2 Predictions**

Based on the remarkable similarities in performance between the hearing bimodal bilinguals and the Deaf bimodal bilinguals with CIs discussed in Chapter 3, no differences are expected between the two groups in overall accuracy or frequencies of error types. Furthermore, all of these children were also included in a separate study of language acquisition in Deaf bimodal bilinguals with CIs (Davidson et al., 2014), which found that language outcomes, as assessed by a number of standardized tests, did not differ between the two groups. Because this task uses elicitation rather than spontaneous speech, both groups are expected to make more mistakes than in spontaneous speech samples. Given the lack of evidence for an influence of perceptual salience on morphological development in the spontaneous speech study, it is also not expected to be a factor in this study.

## **4.3 Method**

### 4.3.1 Participants

Seven hearing bimodal bilinguals (aged 5;01-6;03) and five Deaf bimodal bilinguals with a CI (aged 4;01-6;05) participated in this study. All participants had at least one deaf parent and acquired ASL from birth. The hearing children were also exposed to English from birth, whereas the children who were born deaf began acquiring English once their implant was activated. While the two groups were matched for chronological age (Mann-Whitney  $U(10)=16$ ,  $Z=-.244$ ,  $p=.876$ ), the hearing age of the deaf group was significantly lower than that of the hearing group ( $U(10)=0$ ,  $Z=-2.872$ ,  $p=.003$ ). Table 4.1 presents each child's hearing status, languages of exposure, chronological age (CA), hearing age (HA), age of implant activation (AOIA) and mother's education. Table 4.2 provides the means and standard deviations of the ages of each group. The three hearing bimodal bilinguals (Ben, Lex and Tom) and two of the three Deaf bimodal bilinguals with CIs (Gia and Nik) that participated in the longitudinal also participated in this study.

**Table 4.1: Participant Information for Elicitation Study**

<b>Pseudo</b>	<b>Status</b>	<b>Language Input</b>	<b>CA</b>	<b>HA</b>	<b>AOIA (2nd Implant)</b>	<b>Mother's Education</b>
Ben	Hearing	English & ASL	6;00	6;00	N/A	16+
Kim	Hearing	English & ASL	5;02	5;02	N/A	16+
Lex	Hearing	English & ASL	5;10	5;10	N/A	16+
Lyn	Hearing	English & ASL	6;03	6;03	N/A	12
Tom	Hearing	English & ASL	6;00	6;00	N/A	16+
Val	Hearing	English & ASL	5;02	5;02	N/A	16+
Zig	Hearing	English & ASL	5;01	5;01	N/A	13
Fin	Deaf w/CI	English & ASL	5;08	4;01	1;07	16+
Gia	Deaf w/CI	English & ASL	5;07	4;00	1;07	16+
Max	Deaf w/CI	English & ASL	6;05	4;09	1;08	16
Nik	Deaf w/CI	English & ASL	5;06	4;02	1;04 (3;06)	16
Pam	Deaf w/CI	English & ASL	4;01	1;02	2;11	16

**Table 4.2: Summary of Elicitation Study Participant Ages**

<b>Group</b>	<b>Chronological Age (SD)</b>	<b>Age of Implant Activation (SD)</b>	<b>Hearing Age (SD)</b>
<b>Hearing</b>	5;07.21 (0;05.26)	N/A	5;07.21 (0;05.26)
<b>Deaf w/CI</b>	5;05.12 (0;10.05)	1;09.24 (0;07.16)	3;07.18 (1;04.28)

### 4.3.2 Data Collection

The data from this study came from short videos (about 5-10 minutes) collected at “language fairs” in which bimodal bilingual children took a series of standardized language tests and played language games designed to elicit particular types of language constructions (Quadros, Chen Pichler, Lillo-Martin, Cruz, Kozak, Palmer, Pizzio & Reynolds, 2015). The standardized tests included assessments such as the Preschool Language Scales 4, Expressive Vocabulary Test 2, and the Goldman-Fristoe Test of Articulation 2, the results of which are presented in Davidson et al. (2014). This dissertation analyzed language samples from only two tasks, called the verbal morphology and narrative tasks. The order in which children were administered these standardized tests and language games was randomized.

In the verbal morphology task, children were shown cards with four similar pictures. They had to describe the picture outlined in yellow so that an experimenter could match the picture to one on their card (which did not have a yellow outline). This was thought to be a good test of verbal morphology because the children had to describe the pictures by telling what the animal or animals were doing in each one, eliciting number and tense agreement with singular and plural subjects. For example, the verbal morphology card shown in Figure 4.1 should elicit a description such as “*a man is washing a cup.*” This example was considered the training item and the experimenter was allowed to give an example description if the child did not seem to understand the instructions. These cards were developed specifically for this task and the remaining ten cards can be found in Appendix D. All children received all eleven items in the same order.



**Figure 4.1: Example Verbal Morphology Test Card**

In the narrative task, children watched short animated videos or were shown a series of pictures that depicted a story. They then had to tell the story to an experimenter who had not seen the video or the pictures. The videos were short (under two minutes) excerpts from the French television series *Minuscule –The Private Life of Insects*. There were two different sets of pictures used for the picture narrative task. The first are from the picture book *Tuesday* by David Wiesner. The second set of pictures was developed specifically for this task and is included in Appendix E. Unfortunately, these data came from three different language fairs and all children did not receive the same version of the narrative task (although all did receive the same version of the verbal morphology task). Table 4.3 shows which child received which version of the task. For a more comprehensive description of how children were administered all of the tests/tasks in this larger study of bimodal bilinguals, see Quadros et al. (2015).

**Table 4.3: Form of Narrative Task Given to Each Participant**

<b>Pseudonym</b>	<b>Status</b>	<b>Narrative Form</b>
Ben	hearing	Minuscule
Kim	hearing	Minuscule
Lex	hearing	Minuscule
Lyn	hearing	Narrative Pictures
Tom	hearing	Minuscule
Val	hearing	Minuscule
Zig	hearing	Narrative Pictures
Fin	Deaf w/CI	Tuesday
Gia	Deaf w/CI	Minuscule
Max	Deaf w/CI	Tuesday
Nik	Deaf w/CI	Tuesday
Pam	Deaf w/CI	Tuesday

### **4.3.3**

### **4.3.4 Coding**

Coding was done as described in Section 2.3.3 with the exception that all utterances not excluded as interjections, imitations, repetitions, or unintelligible were included. This was done to maximize the language sample provided by each child in the short videos. Table 4.4 shows the total number of utterances produced by each child in each task, as well as the averages of each group. MLU calculations were based on a total of 50 utterances, half drawn from each task, if possible.

**Table 4.4: Number of Utterances Used in Elicitation Study**

<b>Pseudonym</b>	<b>Status</b>	<b>Verbal Morphology</b>	<b>Narrative</b>	<b>Total Utterances</b>
Ben	hearing	57	142	199
Kim	hearing	24	61	85
Lex	hearing	62	166	228
Lyn	hearing	28	77	105
Tom	hearing	129	121	250
Val	hearing	63	128	191
Zig	hearing	61	82	143
<b>Average</b>		<b>60.6</b>	<b>111.0</b>	<b>171.6</b>
Fin	Deaf w/CI	68	62	130
Gia	Deaf w/CI	44	38	82
Max	Deaf w/CI	50	41	91
Nik	Deaf w/CI	54	62	116
Pam	Deaf w/CI	94	110	204
<b>Average</b>		<b>62.0</b>	<b>62.6</b>	<b>124.6</b>

**Table 4.4 Number of Utterances Used in Elicitation Study**

### **4.3.5 Analyses**

See Section 2.3.4

### **4.3.6 Reliability**

See Section 2.3.5

## 4.4 Results

### 4.4.1 MLU

Table 4.5 shows the means, standard deviations (SD) and ranges of MLU in words and morphemes for the two bilingual groups. Mann-Whitney U tests showed no significant differences between the two groups whether MLU was measured in words ( $U(10)=14$ ,  $Z= -.568$ ,  $p=.639$ ) or morphemes ( $U(10)=11$ ,  $Z=-1.056$ ,  $p=.343$ ).

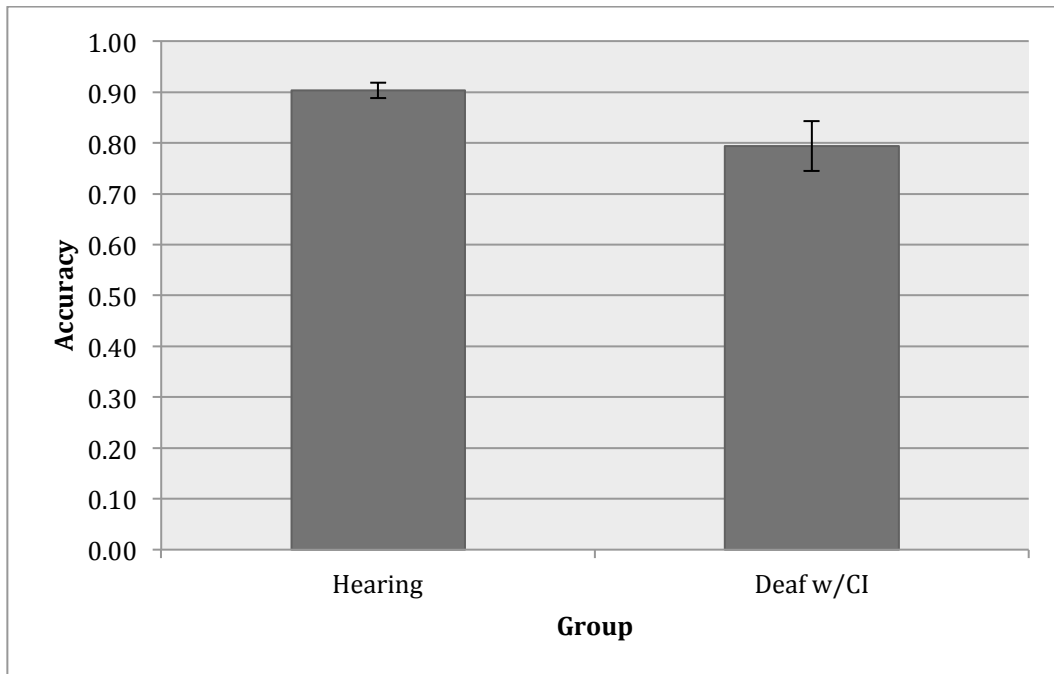
**Table 4.5: Elicitation MLU Results by Group**

Group	MLU <sub>w</sub> (SD)	Range	MLU <sub>m</sub> (SD)	Range
Hearing	4.81 (.55)	3.7-5.36	5.68 (.51)	4.62-6.22
Deaf w/CI	4.75 (.67)	4.16-5.86	5.54 (.65)	5.04-6.66

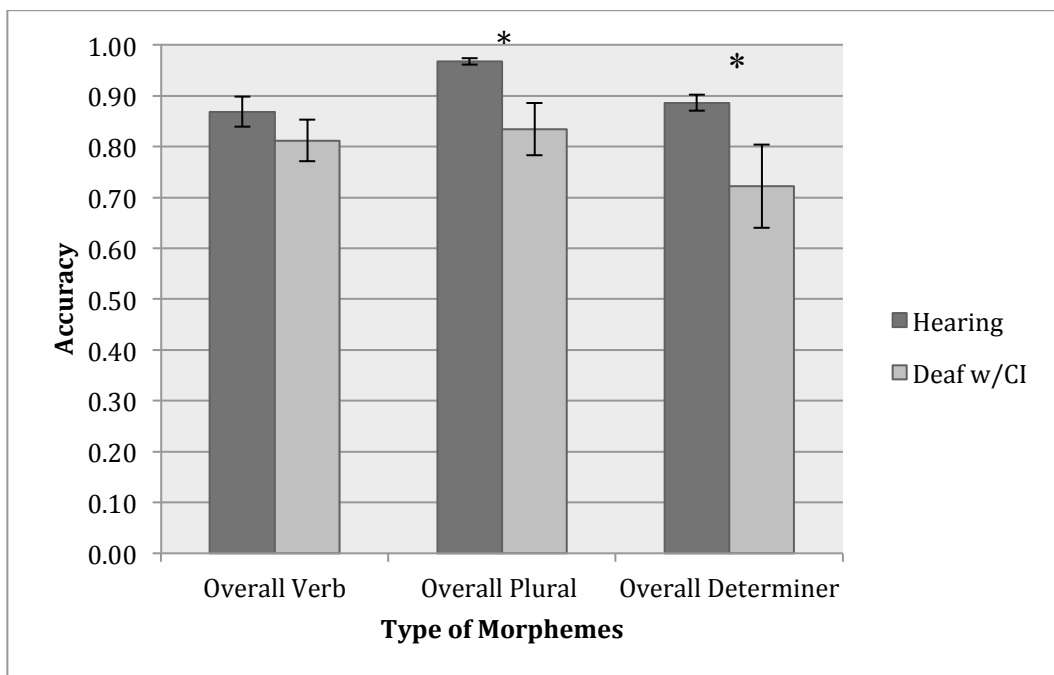
### 4.4.2 Overall Accuracy

Figure 4.2 shows the overall accuracy of the two groups across all morpheme types and Figure 4.3 breaks this information down into verbal, plural and determiner morphemes. Although the measure of overall accuracy across all morpheme types only approached significance (Mann Whitney  $U(10)=6$ ,  $Z=-1.901$ ,  $p=.073$ ), there was a significant difference between the two groups for performance with plural ( $U(10)=.5$ ,  $Z=-2.775$ ,  $p<.01$ ) and determiner ( $U(10)=3$ ,  $Z=-2.38$ ,  $p<.05$ ) morphemes. There was no difference between groups on accuracy rates with all verbal morphemes ( $U(10)=11.5$ ,  $Z=-.978$ ,  $p=.343$ ). Overall plural accuracy includes both regular and irregular nouns, and overall verbal morphological accuracy includes all possible tense/aspect morphemes, not only those broken down in Section 4.4.3.



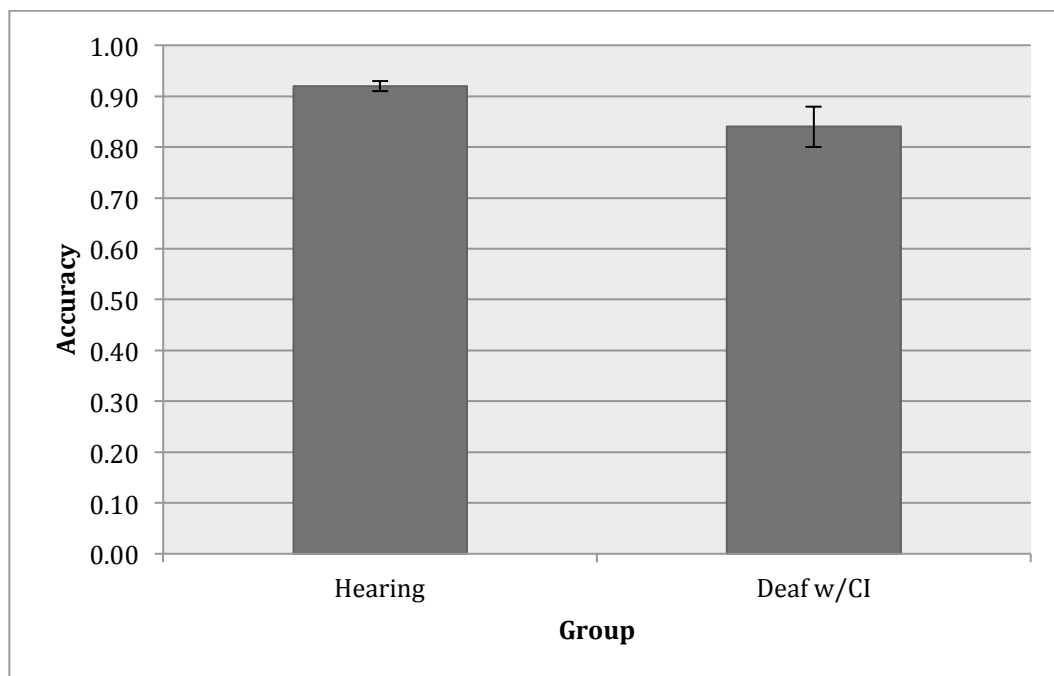


**Figure 4.2: Elicitation Study Overall Accuracy by Group**

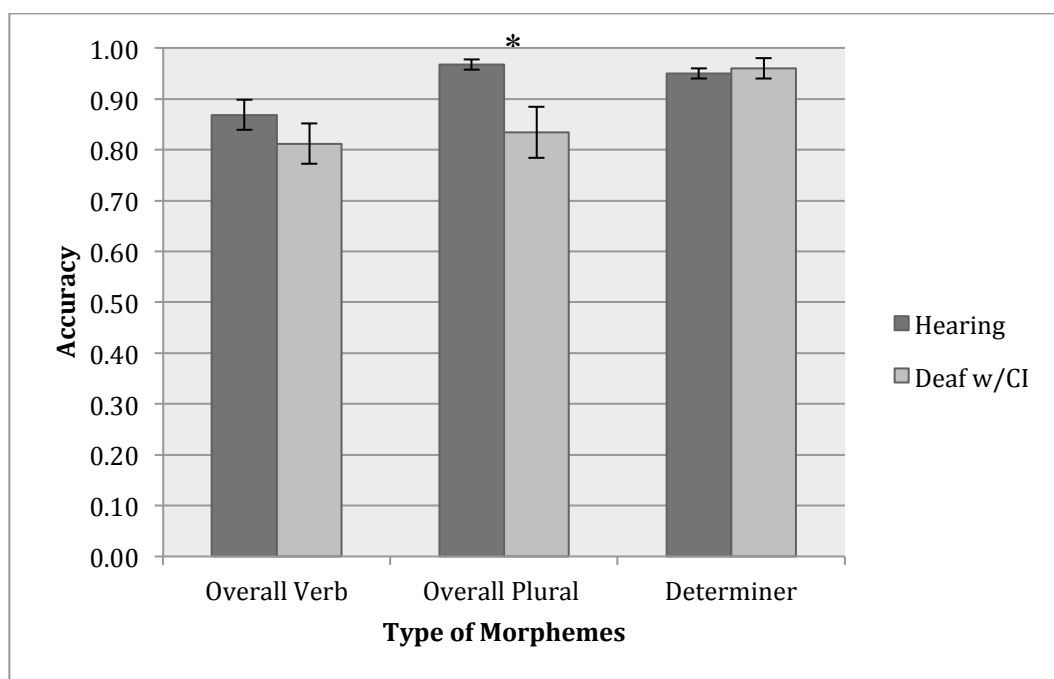


**Figure 4.3: Elicitation Study Overall Accuracy for Different Morpheme Types by Group**

An additional analysis of results was performed with pragmatic determiner errors removed. This was done because all children did not receive the same narrative task; in fact, most of the hearing bimodal bilinguals received the video version of the task, while the Deaf bimodal bilinguals with CIs received a picture version of the task. In the video version of the task, the child had to describe a video to a researcher who was not in the room while the video played. In the picture version of the task, the researcher could not see the pictures, but was in the room while the child looked at and described the pictures. This difference could have made determiner choice a more difficult task for the children. Although it's not clear whether task type actually caused an increase in pragmatic errors, removal of pragmatic errors brought the two groups closer together, as can be seen in Figures 4.4 and 4.5. There was no difference in overall accuracy between the two groups ( $U=8$ ,  $Z=-1.551$ ,  $p=.149$ ). There is no longer a difference between the two groups' accuracy with determiners ( $U=11.5$ ,  $Z=-0.8932$ ,  $p=.373$ ).



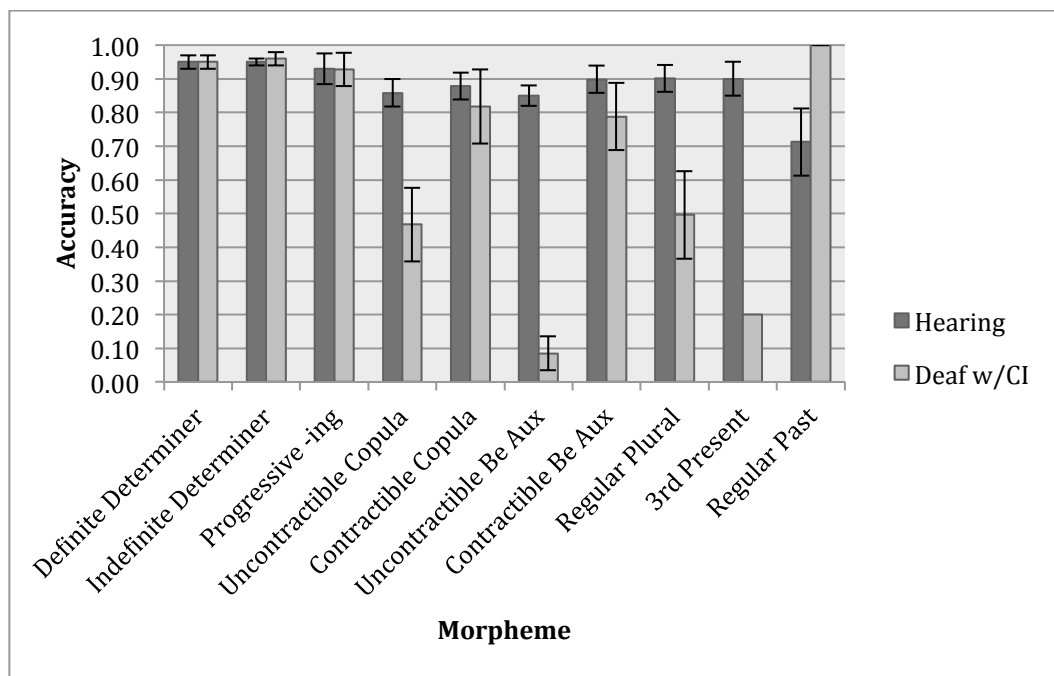
**Figure 4.4: Elicitation Study Overall Accuracy without Pragmatic by Group Errors**



**Figure 4.5: Elicitation Study Overall Accuracy without Pragmatic Errors for Different Morpheme Types by Group**

#### 4.4.3 Individual Morpheme Performance

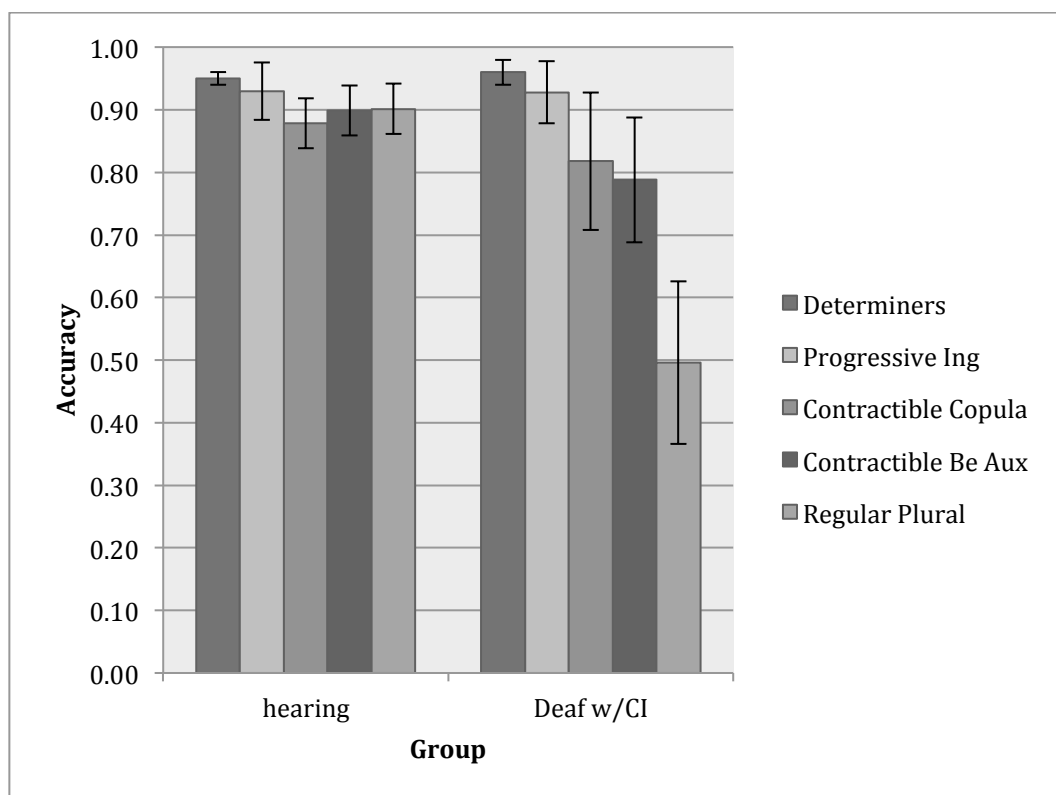
Figure 4.6 provides mean accuracy on ten different English morphemes by group. This graph should be interpreted cautiously because four of the ten morphemes lack data from all subjects (uncontractible copula, uncontractible auxiliary, 3<sup>rd</sup> person present and regular past). The means for these morphemes are thus based on small numbers of children. The Deaf with CI group performed as well as, or better than, the hearing group on six of ten morphemes. The four morphemes that the Deaf with CI group had the most problems with were the uncontractible copula, uncontractible be auxiliary, regular plural *-s*, and 3<sup>rd</sup> person present *-s*. Individual morpheme performance will be discussed further in the next section.



**Figure 4.6: Elicitation Study Group Accuracy by Morpheme**

#### 4.4.4 Perceptual Salience Hypothesis

Because only six morphemes met the minimum of four obligatory contexts in all children, only results from these morphemes will be utilized to address the predictions of the perceptual salience hypothesis. These results are presented again in Figure 4.7, but this time grouped by hearing status rather than morpheme. Table 2.3 is repeated below as Table 4.6 to show that the perceptual salience hypothesis, as described in Chapter 2, does not predict differing acquisition times for all six morphemes. For instance, no distinction was made between the contractible copula and auxiliary.



**Figure 4.7: Elicitation Study Accuracy by Morpheme in Order of Perceptual Salience at Age 5**

**Table 4.6: Morphemes from Most to Least Perceptually Salient**

Morpheme	Acquisition	Notes
a(n)/the; uncontractible copula & auxiliary	Earlier	full independent words
progressive <i>-ing</i>	↑	syllabic
contractible copula & auxiliary		longer duration and high frequency, sometimes uncontracted
3rd present & plural <i>-s</i> ;	↓	longer duration and high frequency
past <i>-ed</i>	Later	short duration, lower frequency

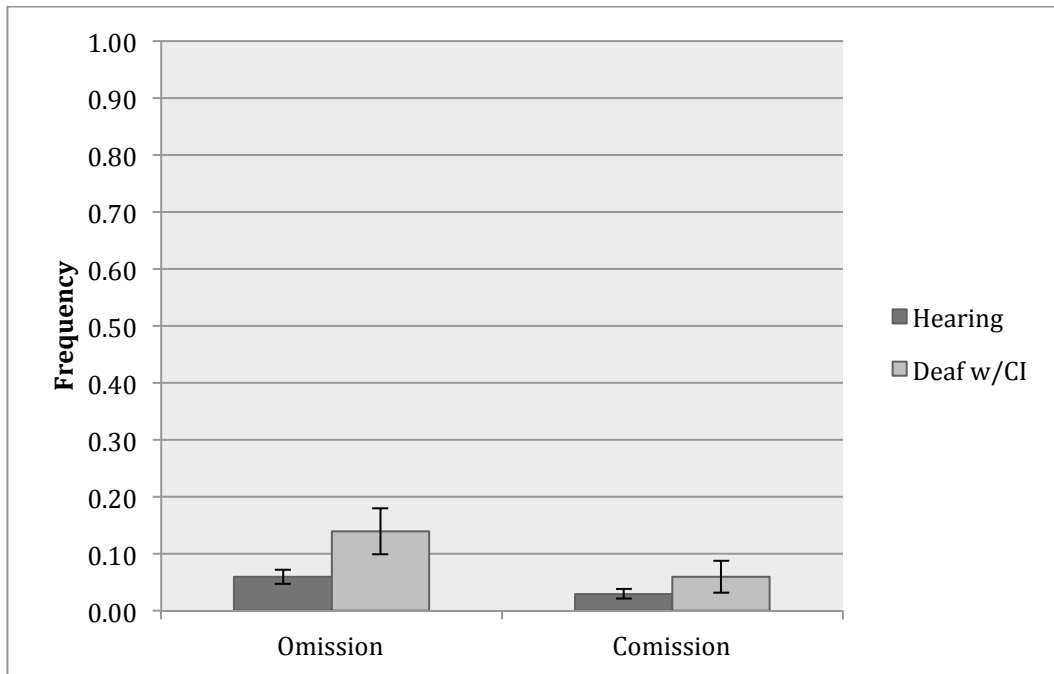
A Friedman test showed that, for the hearing bimodal bilingual group, there was no significant difference in accuracy rate across morphemes ( $\chi^2(5) = 3.933, p = 0.559$ ). For the Deaf bimodal bilinguals with CIs, there was a significant difference in accuracy rates across

morphemes ( $\chi^2(5) = 16.623, p = 0.005$ ). Post hoc analysis with Wilcoxon signed-rank tests was conducted. Only six comparisons were made based on the predictions of the perceptual salience hypothesis: (1) determiner and plural (2) determiner and contractible auxiliary (3) determiner and progressive (4) progressive and contractible auxiliary (5) progressive and plural (6) contractible auxiliary and plural. Contractible copula was not used for comparisons because data was not available from one subject (Pam).

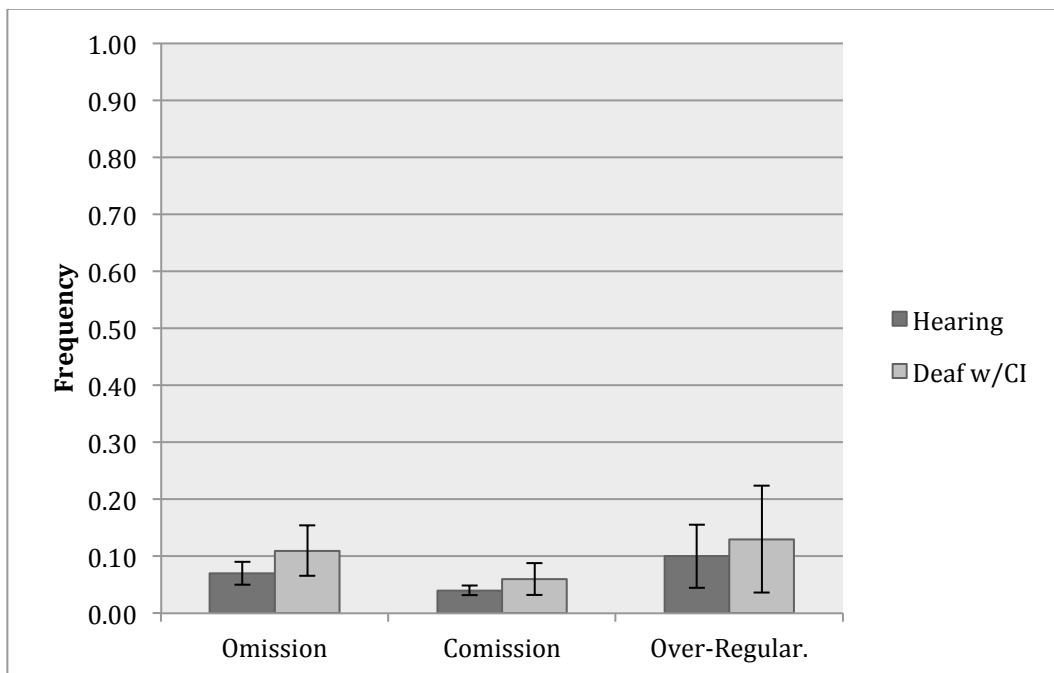
The significance value was adjusted to .008 (.05/6) to compensate for the multiple comparisons. Given this stringent probability and the small sample size, none of the five comparisons reached the level of significance. The results for the six comparisons were (1)  $Z = -0.365, p = .715$ , (2)  $Z = -1.753, p = .08$  (3)  $Z = -2.023, p = .043$  (4)  $Z = -1.826, p = .068$  and (5)  $Z = -2.023, p = .043$  (6)  $Z = -2.023, p = .043$ .

#### **4.4.5 Error Type Frequencies**

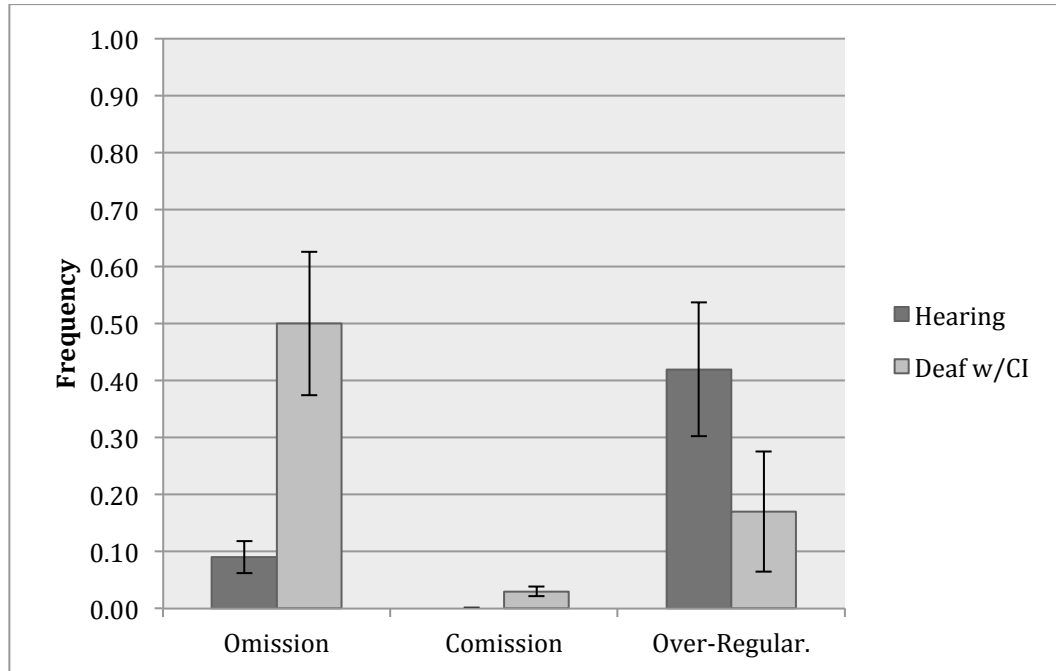
Figures 4.8-4.11 show the frequencies of error types in the two groups for all morphemes as well as broken down into the three different morpheme types (verbal, plural and determiner). As Figure 4.8 shows, omission errors are more common than commission errors for both groups. The overall pattern for verbal morphology is similar for both groups. However the pattern for plural error types seems very distinct between the two groups with the Deaf bimodal bilinguals with CIs making many more errors of omission than the hearing group and the hearing bimodal bilinguals over-regularizing much more frequently than the CCI group. Lastly, both groups were most likely to make pragmatic errors with determiners than omission or commission errors.



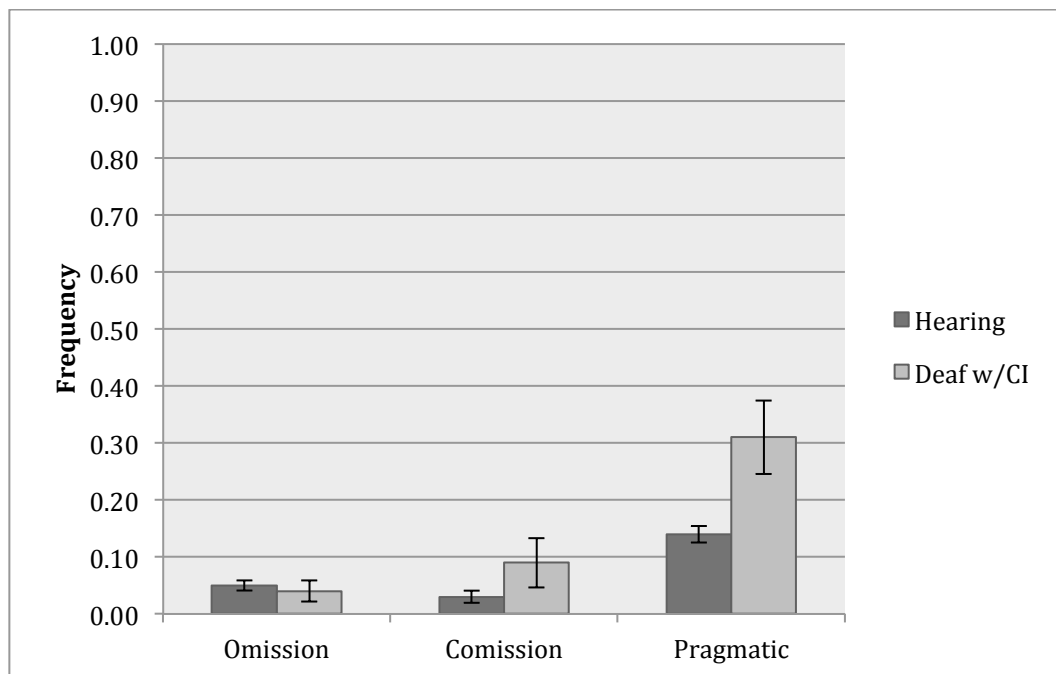
**Figure 4.8: Elicitation Study Overall Error Type Frequencies**



**Figure 4.9: Elicitation Study Overall Verb Error Type Frequencies**



**Figure 4.10: Elicitation Study Overall Plural Error Type Frequencies**



**Figure 4.11: Elicitation Study Overall Determiner Error Type Frequencies**



#### 4.4.6 Age of Implantation and Overall Accuracy

Although we did not have enough children to statistically investigate the relationship between age of implant activation and morphological accuracy, Figure 4.12 provides a scatterplot of the data from the five Deaf bimodal bilinguals with CIs. From this plot, there is no clear trend of earlier implantation/implant activation leading to better performance.

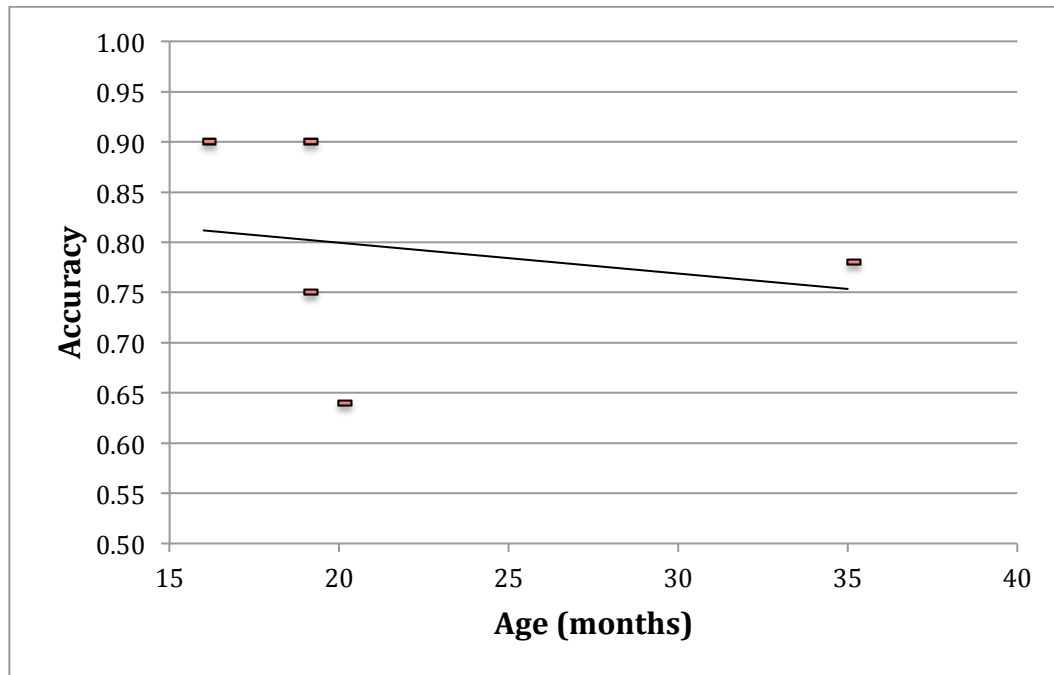
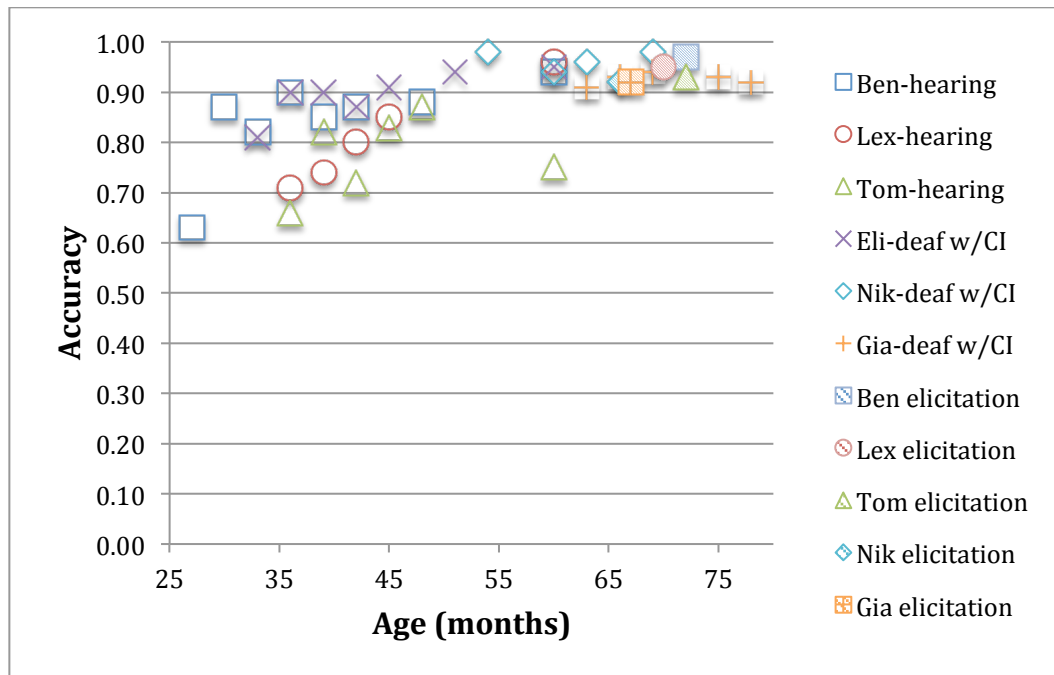


Figure 4.12: Overall Accuracy by Age of Implant Activation

#### 4.4.7 Comparing Longitudinal and Elicitation Data

Because five of the six children who were in the longitudinal study also participated in the elicitation tasks, it is possible to compare their performance. As can be seen in Figure 4.13, the three hearing bimodal bilinguals (Ben, Lex and Tom) were older at the time of the elicitation study while the two Deaf bimodal bilinguals with CIs (Gia and Nik) participated in the elicitation study while their longitudinal data was still being collected and analyzed for this study. All of

these five data points fall within the range of accuracy (90-100%) seen in the Deaf bimodal bilinguals with CIs from age 5;00-6;06 (60-78 months), as discussed in Chapter 3.



**Figure 4.13: Overall Accuracy by Chronological Age Including All Data**

## 4.5 Discussion

When comparing the hearing bimodal bilinguals to the Deaf bimodal bilinguals with CIs based on MLU in words and morphemes, both groups' language development looked comparable. Furthermore, the difference in overall accuracy between the two groups only approached significance. Despite these facts, there were significant differences between the two groups in plural and determiner accuracy, with the hearing bimodal bilinguals outperforming the Deaf bimodal bilinguals with CIs. When pragmatic determiner errors were removed, there was no longer a difference between these two groups on accuracy. It is not clear whether the

difference in task or some other, child internal factors caused the children with CIs to make more pragmatic errors with determiners. These results could mean that verbal morphology is a relative strength for these Deaf bimodal bilinguals with CIs, while plurals and (possibly) determiners are weaknesses. This conclusion may not yet be warranted though, because our elicitation method failed to obtain large numbers of regular past tense, which is an important tense morpheme that may be of particular difficulty for children with CIs generally based on its low perceptual salience.

When accuracy by individual morphemes was separated out, there was limited evidence for the influence of perceptual saliency, but only for the children with cochlear implants. It is possible that perceptual salience is an important factor for younger hearing bimodal bilinguals, but the children in this study were too old to show such an effect. The Deaf bimodal bilinguals with CIs performed more accurately with progressive *-ing* than plural *-s* even at this late age, suggesting that perceptual saliency is important to children with CIs after any possible effect in hearing children has dissipated. Inclusion of more children at younger ages and a methodology to target additional morphemes, such as regular past tense, would help clarify the role of perceptual salience in morphological acquisition.

As has been found in research on monolinguals, unimodal bilinguals and in the longitudinal data for both groups of bimodal bilinguals, omission errors occur more frequently than errors of commission. Although both groups made over-regularization errors with verbs at similar frequencies, there was some evidence that hearing bimodal bilinguals were more likely to over-regularize nouns while Deaf bimodal bilingual with CIs more commonly omitted the plural morpheme. It could be that a similar pattern would also have emerged with verbal morphology had there been more instances of past tense in our data. It is reasonable to expect more frequent

errors of omission with low saliency morphemes from all children with cochlear implants if their implants do not always detect and convey them effectively, causing difficulty in morphological rule acquisition.

For determiners, both groups most commonly made pragmatic errors. This is likely a task effect because such a pattern was not observed in the longitudinal data from spontaneous speech. In the context of the spontaneous speech samples, both the researcher and child were engaged in cooperative play and, for the most part, had shared attention to the toys and people they were interacting with. In the context of the elicitation tasks, the child had to describe pictures or stories to someone who had not seen them before and therefore had to consider what was new or old information before using a determiner. This led to many more opportunities for pragmatic errors.

When age of implant activation was considered as a factor predicting performance in the Deaf bimodal bilinguals with CIs, there was no trend toward earlier implantation leading to better performance. This contradicts a number of previous studies that have found such a relationship (see Section 1.5.5). This difference could be due to the limited number of children in our study and the fact that other factors that have been shown to affect performance were not controlled for (e.g., pre-implant hearing abilities). Additionally, all five of the Deaf bimodal bilinguals with CIs were implanted before age three, which may not provide enough variability in age of implant activation to show effects on language outcomes.

Finally, the comparison between the spontaneous and elicitation data suggests two important points. The task type may not have been that important, because accuracy rates did not vary much between spontaneous and elicited speech samples. Additionally, the plateau in performance seen in the older Deaf bimodal bilinguals with CIs is similar to the pattern of morphological development that was also seen in hearing bimodal bilinguals.

This leaves the question of why group differences were apparent in the elicitation study but not the longitudinal study (see Chapter 3). One possibility is that the Deaf bimodal bilingual with CI participants in the longitudinal study do not represent their population as a whole. In fact, the two bimodal bilinguals who participated in both portions of this study (Gia and Nik) happened to be the top performers in the elicitation study. Yet the three hearing bimodal bilingual participants in the longitudinal study also participated in the elicitation study and achieved the three highest accuracy rates for their group as well (although this group did not have as much variation in performance). Future research should include larger sample sizes for both groups to address this issue of representation. It is clear though that deaf children who receive cochlear implants but are also exposed to sign language can have similar spoken language outcomes to their hearing bimodal bilingual peers.

## Chapter 5: Conclusion

In this chapter, the results from Chapters 2, 3 and 4 are first summarized in Sections 5.1, 5.2 and 5.3. Section 5.4 compares the results from the spontaneous speech samples to the elicited speech samples. Section 5.5 reviews the limitations of this study while 5.6 discusses its importance. Section 5.7 discusses ways in which this research can be expanded and extended.

### 5.1 English Morphological Development in the Spontaneous Speech of

#### Hearing Bimodal Bilingual Children

The English morphological development of three hearing bimodal bilinguals was analyzed in spontaneous speech samples from ages 2;03-5;00. Given the wide variability in monolingual morphological development, there was little evidence that these bimodal bilingual children were behind their monolingual English-speaking peers. For example, the MLU results were within one standard deviation of the monolingual means from Thordardottir (2014). Despite this, there was some evidence that these bimodal bilinguals were less accurate compared with their monolingual peers with plural *-s*. There was also mixed evidence for a delay in acquisition of the progressive *-ing* and determiners *a(n)/the*.

The reasons why the plural morpheme is particularly vulnerable are unclear. ASL marks plurality through reduplication of the noun, or inclusion of a numerical or quantificational modifier, but such marking is optional. Yet other morphemes, such as determiners, are also absent or optional, but there was no strong evidence that bimodal bilingual children are less accurate with these morphemes. For morphemes such as the regular past tense *-ed*, this could be due to a lack of obligatory contexts in the spontaneous speech samples analyzed. Inclusion of

more data and alternative research methods, such as an elicitation method targeting past tense, would help determine the status of such morphemes in the language development of hearing bimodal bilinguals.

Another factor that might have conspired against the regular plural *-s* is its low perceptual salience. According to Leonard's (1989) perceptual salience hierarchy, it is one of the least easily perceivable English morphemes and is likely to cause trouble for children. Despite this fact, these three children did not show strong evidence of an influence of perceptual salience. This was due to the high variability in accuracy rates across children, which made determination of such an effect difficult. Again, an inclusion of a greater number of subjects would help determine the role of perceptual salience in the English morphological acquisition of hearing bimodal bilinguals.

The hearing bimodal bilinguals made the same types of errors found in monolingual English-speaking children. Omission of morphemes is the most common error type for both groups. Commission errors, or production of a morpheme in contexts which do not require it, were exceedingly rare, as is the case for monolinguals as well. The rate of over-regularization of irregular nouns and verbs was somewhat low for the hearing bimodal bilinguals, but Marcus et al. (1992) argue that such errors are also rare in the speech of monolingual children. Furthermore, there were few instances of irregular nouns and past tense verbs (regular and irregular) in the speech samples of these children, which made it difficult to find clear patterns for this error type.

These results are consistent with the literature on morphological development in unimodal bilinguals: given the right conditions of language exposure, bilinguals are often indistinguishable from monolinguals. For example, these bimodal bilinguals received about half

of their input in each language, with English exposure increasing as the children began to attend daycare or preschool. Thordardottir (2014) found that balanced French-English bilinguals performed as accurately with English morphology as English-speaking monolinguals and English dominant bilinguals. Furthermore, when one of a bilingual's languages has a minority status in the community and the other a majority status, the minority language is more vulnerable to delayed or disordered acquisition (Unsworth, 2015). This fact suggests that the ASL development of the bimodal bilinguals was at risk more so than English because these children were raised in an English dominant society (the United States of America). This prediction is borne out by our results, in combination with those of Palmer (2015), who found that hearing bimodal bilinguals' acquisition of ASL word order was delayed relative to monolingual Deaf signers. The limited evidence for divergence in English morphological acquisition in the hearing bimodal bilinguals in this study despite the otherwise favorable conditions for English language development suggests that there could be more specific transfer effects from ASL to English only for certain morphemes such as the plural *-s*.

## **5.2 English Morphological Development in the Spontaneous Speech of Deaf**

### **Bimodal Bilingual Children with Cochlear Implants**

The English morphological development of three Deaf bimodal bilinguals with CIs was analyzed from the age of 2;10-6;06. These children were similar to the hearing bimodal bilinguals in the amount of exposure to each of their languages, except that their first auditory exposure to English began only after they received their cochlear implants, at the mean age of 16 months. Unlike many other deaf children who go on to receive CIs, these children had Deaf



parents who were able to sign to them from birth and provide them input in a full, natural language in the manual/visual modality. Results from this study were compared to the hearing bimodal bilinguals to control for any bilingualism effects. Residual differences between these two groups might best be explained by delayed English/auditory input or the realities of electrical hearing through a CI.

MLU results were within the expected range of monolingual English speakers, or quickly reached that range after data collection began. There was not a strong relationship between MLU and morphological accuracy, likely because accuracy was quite high even when MLU was low. Nevertheless, this seems to show dissociation between general language development and morphological accuracy. Such dissociation was not evident in the hearing bimodal bilinguals, whose morphological accuracy increased along with their MLU.

Accuracy rates were similar to those of the hearing bimodal bilinguals and the same morphemes showed evidence of delay, with the plural *-s* apparently the most vulnerable morpheme. There was no evidence that the perceptual salience of morphemes overall was a significant factor affecting accuracy rates, beyond the fact that plural *-s* seemed the mostly likely morpheme to be delayed. As with the hearing bimodal bilinguals and the monolinguals, morphological errors were most often errors of omission, with commission errors occurring infrequently. Again, there were few instances of plural and past tense over-regularization, but also few opportunities for such errors to occur. All of these findings suggest that the delay in access to spoken language is not a critical factor for these children, perhaps because they have early access to a signed language.

### **5.3 English Morphological Development in the Elicited Speech of Hearing and Deaf with Cochlear Implants Bimodal Bilinguals**

Seven hearing bimodal bilinguals (5;01-6;03) and five Deaf bimodal bilinguals (4;01-6;05) who received a cochlear implant by age 2;11 participated in a larger study of the language development of bimodal bilinguals. The two groups were matched on chronological age, but not hearing age. As part of this study, the children took standardized language tests and participated in tasks meant to elicit particular types of language. English morphology was analyzed in two tasks for this study: the narrative task and the verbal morphology task.

While MLU, overall morphological accuracy, and accuracy with verbal morphemes and determiners did not differ between the two groups, the Deaf bimodal bilinguals were significantly less accurate than the hearing participants with plural morphology. This was largely due to a higher rate of omission of the regular plural morpheme *-s* in this group. Hearing bimodal bilinguals seemed to over-regularize the plural morpheme more frequently than the Deaf group, although this was based on an overall small number of irregular nouns. There was also evidence that the perceptual salience of morphemes influenced children's accuracy rates for the Deaf group and not the hearing group. Age of implantation did not seem to affect performance, although the sample size was small and limited to children who received their CI at relatively young ages.

## **5.4 Comparison of Morphological Development in Spontaneous and Elicited Speech of Bimodal Bilinguals**

Three of the hearing and two of the Deaf bimodal bilinguals participated in both the longitudinal, spontaneous speech study and the elicited speech study. For the hearing group, the spontaneous speech data only covered through age 5;00, while the data from the Deaf group generally started later and ended at age 6;06. Because of this, it was difficult to tell how similar the two groups were beyond age 5;00. When performance was compared across tasks, all participants followed the same developmental trend, with improving accuracy that levels out around 90-95% accuracy by age 5;00. This suggests that the spontaneous speech data from the Deaf bimodal bilinguals beyond age 5;00 likely resembles what would have been found from hearing bimodal bilinguals in spontaneous speech at older ages. This reinforces the overall conclusion that Deaf bimodal bilinguals' morphological development is remarkably similar to that of hearing bimodal bilinguals who experienced no delay in exposure to English. This is a bit surprising because many other authors have found deficits in the morphological development of monolingual children with CIs (see Chapter 3 for a review). It could be that early exposure to a full, natural language (ASL) from birth improved English language outcomes in the bimodal bilingual children with CIs, although direct comparison with monolingual children with CIs is necessary to directly address this issue.

It is also a bit surprising that performance was so similar between the elicited and spontaneous speech samples. Children might be expected to be less accurate in elicited speech tasks because they are in a way “forced” to use grammatical constructions that they have not yet fully figured out and would avoid using under normal circumstances. Yet the elicited speech tasks used in this study, while targeted at specific constructions (i.e., verbal morphology and

narrative structure), did not use elaborate lead-ins to force the children to use particular forms. The children were generally still free to avoid using constructions they were less comfortable with, except of course for morphology such as verbal agreement and tense.

## **5.5 Limitations of This Study**

This study included a small number of subjects, and while development was analyzed over a large age range, the data within this age range was only analyzed in three month intervals. Sampling at roughly one month intervals, while quite time demanding to analyze, might allow additional, less frequent, morphemes to be included. Additionally, the elicitation tasks were not particularly good at getting the children to produce some morphemes such as the regular past tense, which are important, and highly relevant to questions of perceptual salience.

Both the hearing and Deaf bimodal bilinguals were of relatively high SES, with most mothers having completed an advanced degree. This means that results may not generalize to other children of Deaf parents, because this level of academic achievement is uncommon in the Deaf population. Additionally, it may not generalize to children of hearing parents of low SES. There is an added complication in that most deaf children are born to hearing, non-signing parents. These parents, if they choose to expose their child to sign language at all, only learn sign language after their child receives a diagnosis of hearing loss. It is not clear whether exposure to non-native signing will have the same effect as exposure to the fluent signing of Deaf parents.

## 5.6 Importance of This Study

Both the populations of hearing and Deaf with CI bimodal bilinguals are relatively understudied. As discussed in Chapter 2, there are some older studies which mostly find language deficits in the hearing children of Deaf parents, but many of these studies did not consider that these children were bilinguals and, while the end-state of acquisition might be full competence in the spoken language, their developmental trajectory might differ from that of monolingual English speakers.

Studies of Deaf bimodal bilinguals are even more rare, perhaps because this population is so small. Cochlear implantation is still controversial and many Deaf parents do not choose to have their Deaf children receive cochlear implants (Mauldin, 2015; Paludnevičienė & Leigh, 2011). Despite this, results from Deaf bimodal bilinguals such as in this study and in Davidson et al. (2014) are vital to the lives of all deaf children who might receive cochlear implants. This is because many clinicians still dissuade parents from using sign language with their deaf children (Mauldin, 2012) even though they have little to no access to spoken language before implantation or when the CI is not worn or malfunctioning.

Furthermore, studies that have shown that sign language hinders the development of spoken language are confounded by the facts that (1) their signing subjects are usually exposed to some form of total communication (TC) rather than actual ASL and (2) children who do not do well with spoken language alone are often placed in TC settings only after floundering in speech-only environments (Swanwick & Tsverik, 2007). Studies of Deaf bimodal bilinguals have so far demonstrated impressive language outcomes, despite, or perhaps because of, early exposure to a sign language (Davidson et al., 2014; Cruz et al., 2014; this study). While the situation for most deaf children born to hearing parents is different because their parents are not

fluent signers, understanding the language outcomes of Deaf bimodal bilinguals is necessary for parents to make fully informed decisions about the languages they choose to provide their children.

Another important aspect of this study is the use of spontaneous and elicited speech samples. The vast majority of studies on children with CIs use standardized tests which, despite their many advantages, might fail to catch some language deficits. For example, Davidson et al. found that Deaf bimodal bilinguals with CIs performed at or above chronological age level on a handful of standardized language tests, but a more in depth analysis of their morphological development found that these children are not using the English plural *-s* as accurately as would be expected (Chapter 4). Both types of studies are necessary to develop a full picture of language development in children.

## **5.7 Future Research**

While there is still much research necessary to fully understand the overall language development of bimodal bilinguals (hearing and Deaf), a few extensions could be made to this study to improve our understanding of morphological development more specifically. First, more dense and expansive (time-wise) morphological analysis in spontaneous speech would provide a clearer picture of the developmental trajectory of these children and might allow inclusion of additional, less frequently used, morphemes.

Next, inclusion of a group of deaf bimodal bilinguals with CIs from hearing families who have decided to use sign language would show how generalizable the results from the Deaf group in this study are to the broader population of deaf children born to hearing, non-signing

parents. Do the (presumably) lower levels of signing fluency by their hearing parents detrimentally affect spoken language outcomes? Is there a minimum amount of signing input necessary to help/hinder spoken language development? How much is the language choice of the child affected by the signing input provided by their parents? This last question is integral because the impetus behind the denial of sign language to deaf children seems to be the belief that deaf children will choose sign (if provided) over speech because it is easier for them. There are also many additional questions that could be addressed by inclusion of this population.

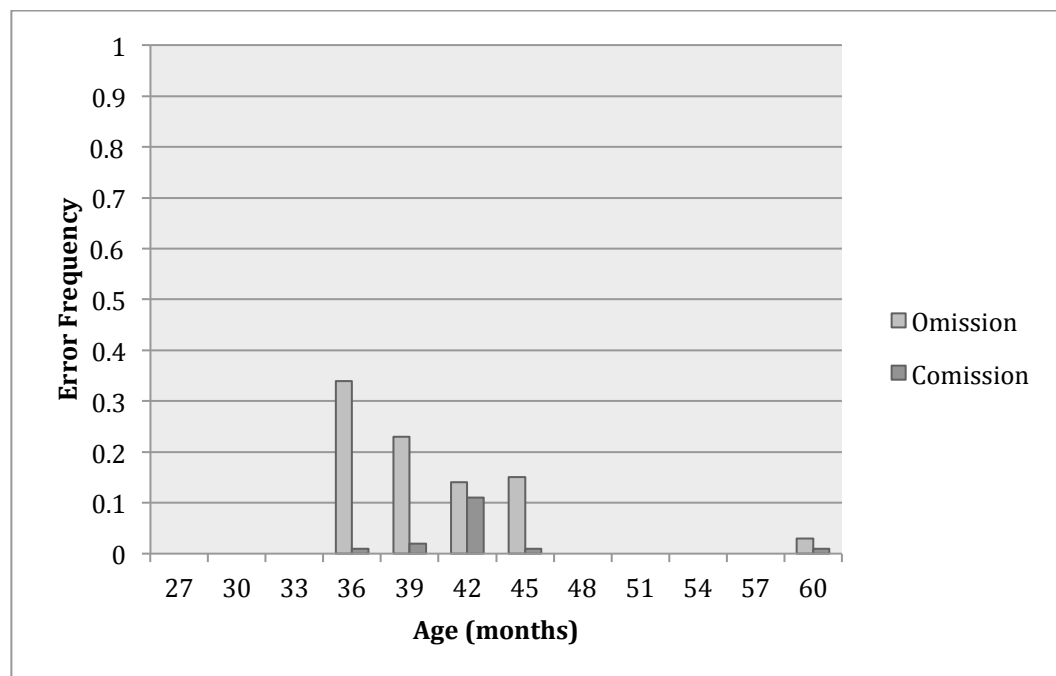
Another area that could be explored further is language transfer of morphology in bimodal bilinguals. For example, when children make mistakes with a morpheme like English plural –s, they might mark it using reduplication, as is done in ASL. Or, if the utterance contains both signs and speech, the plurality of a noun might be marked in ASL but not English. Furthermore, although the modality analysis done in this study concluded that most morphological errors did not occur in code-blended utterances, a higher error rate is expected in such utterances. Analysis of English in ASL target sessions would likely provide many more examples of code-blended speech (Davidson et al., 2013), which, with more detailed analyses, could contribute to the study of language interaction in bilingualism.

## Appendix A: Rules Used to Coded MLU

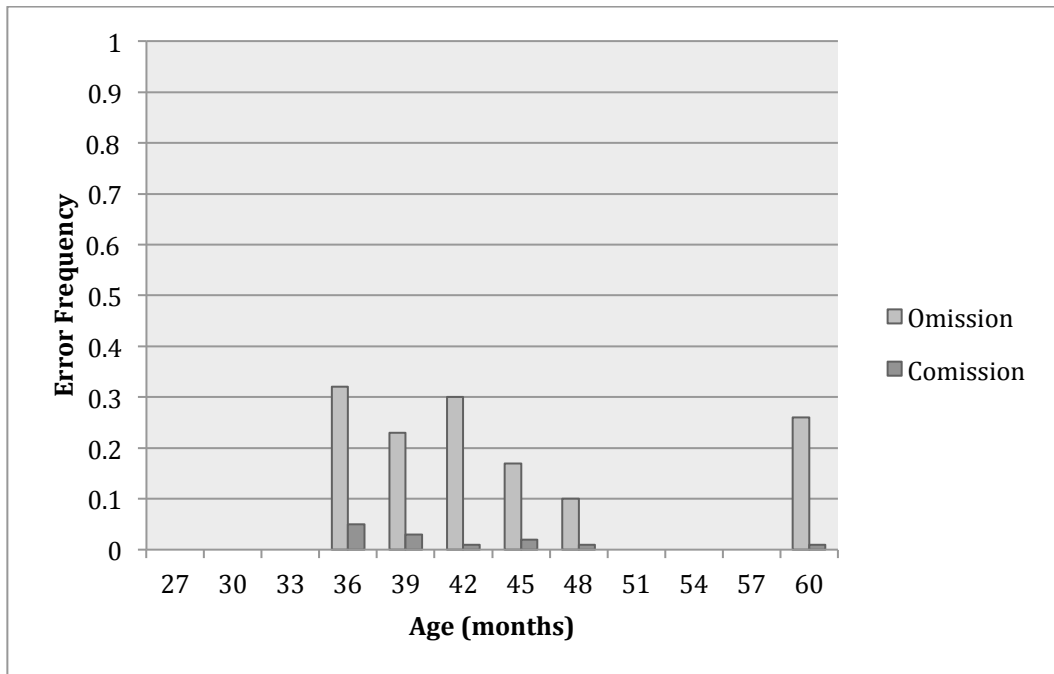
1. MLU<sub>w</sub> is MLU in words and MLU<sub>m</sub> is MLU in morphemes. For MLU<sub>w</sub> you simply count the words in an utterance. For MLU<sub>m</sub>, you include each morpheme in the count. For example, a sentence like *I'm eating grapes* will have only 3 words, but 6 morphemes (pronoun *I*, contracted *am*, verb *eat*, progressive *-ing*, noun *grape* and plural *-s*).
2. Don't include morphemes that shouldn't be there in the MLU count
3. One exception to this is when the morpheme is correct but misplaced, as in "this is bounce" instead of "this bounces"
4. Don't include yes/no at the beginning of utterances in the MLU count
5. *Gonna*, *wanna*, *hafta* all count as one morpheme. *Dunno* should be coded as "don't know"
6. Non-novel compounds, like *peanut butter*, count as one morpheme. Novel compounds count as two.
7. Irregular past tense and plural (*ran*, *children*) count as one morpheme
8. Diminutives (*doggy*) do not count as separate morphemes
9. For false starts and corrections, only count the final version toward MLU
10. In the case of one run on sentence connected by "and", only count up to two conjoined sentences



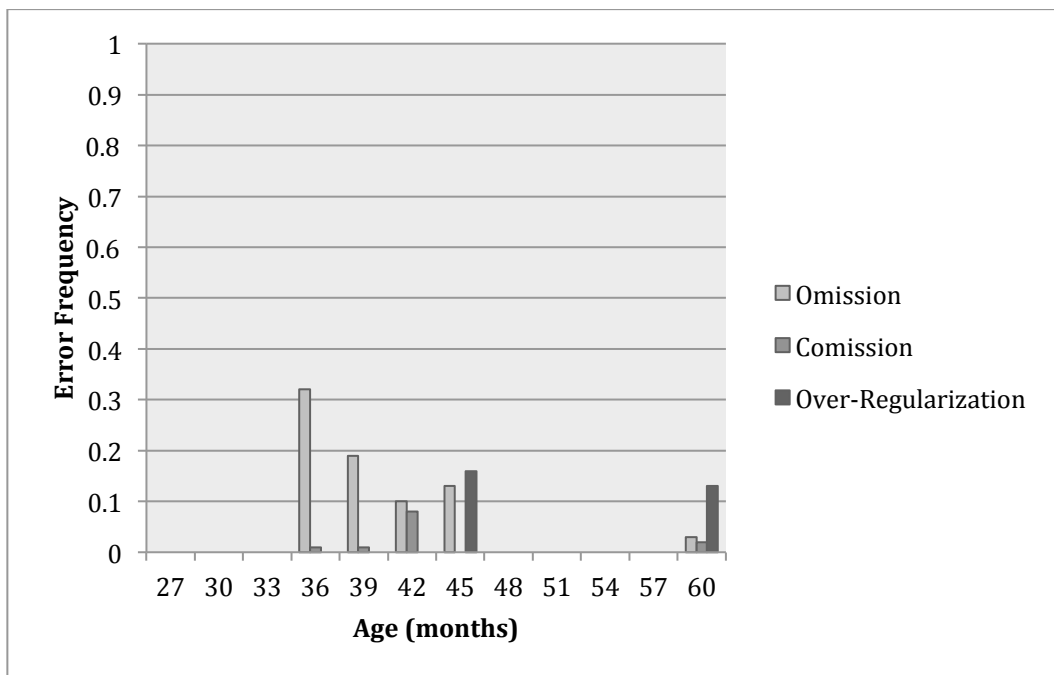
## Appendix B: Hearing Bimodal Bilinguals' Error Type Frequency Figures



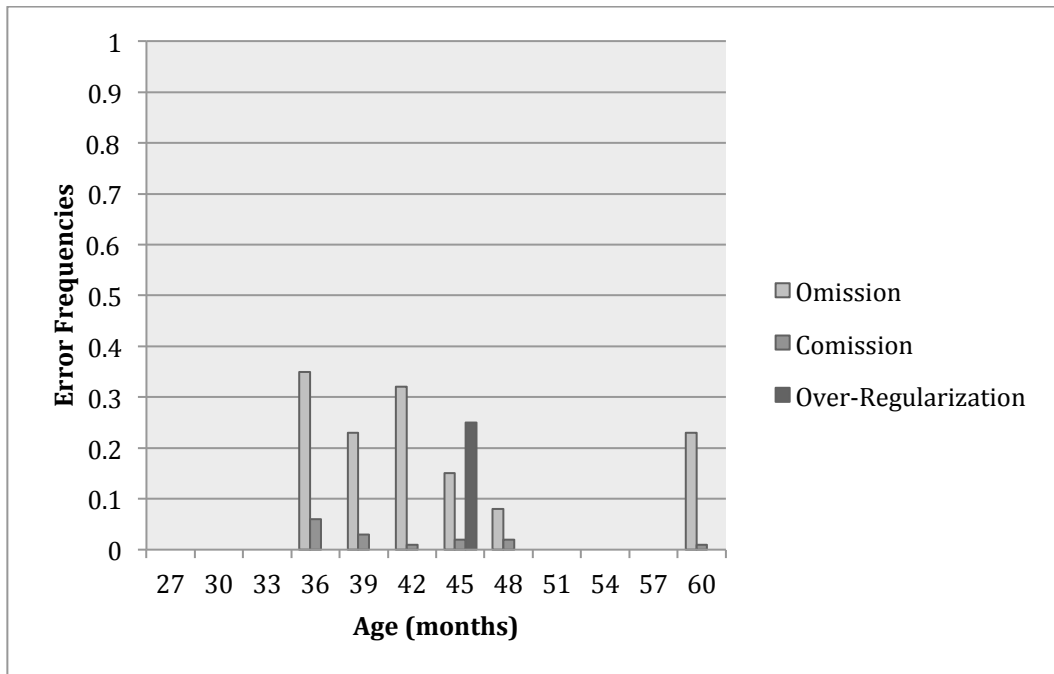
**Figure B.1:Lex's Overall Error Type Frequencies**



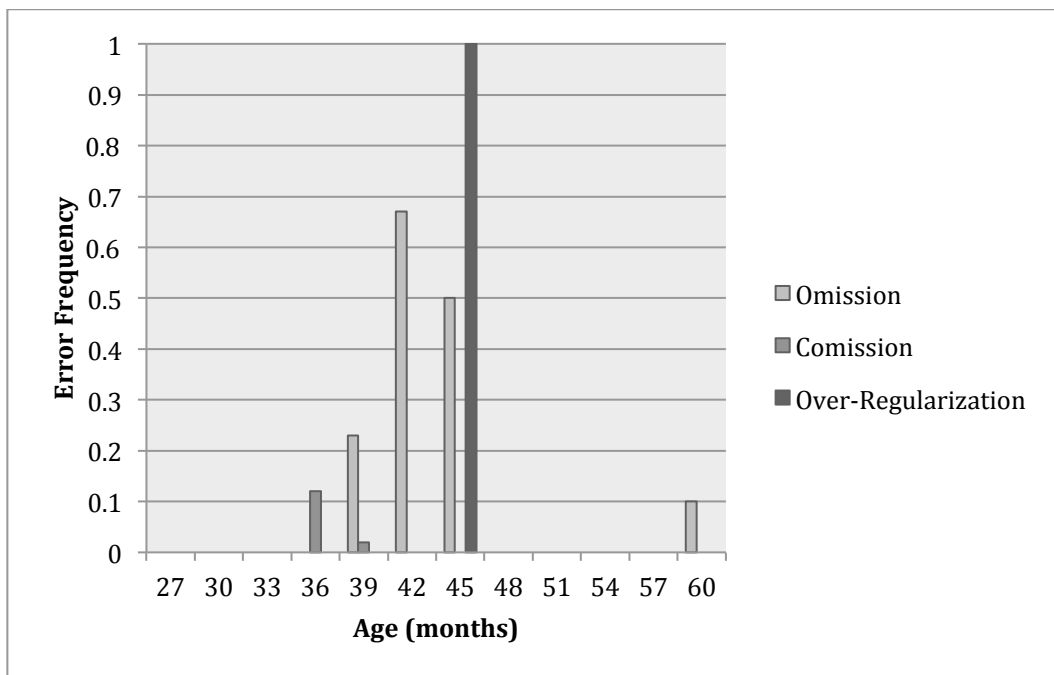
**Figure B.2: Tom's Overall Error Type Frequencies**



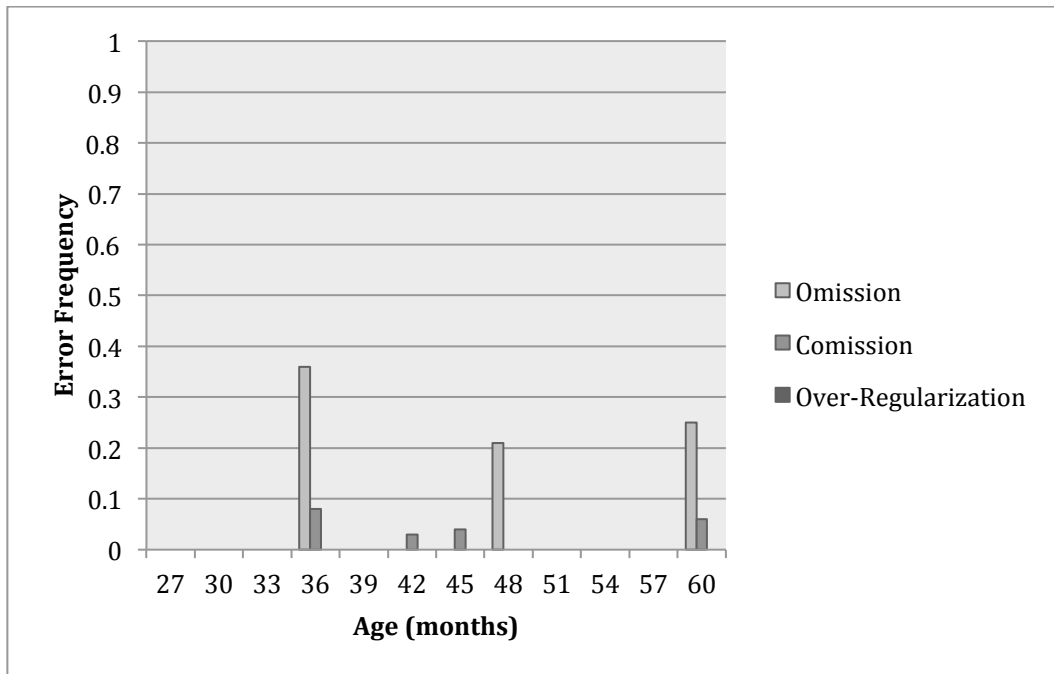
**Figure B.3: Lex's Overall Verb Error Type Frequencies**



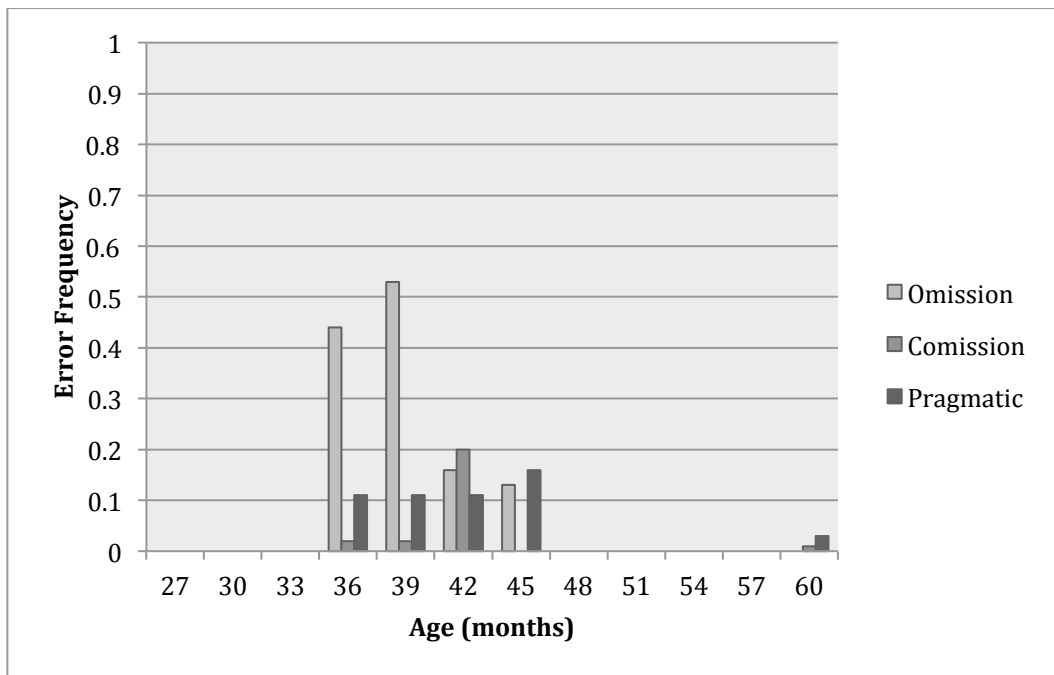
**Figure B.4: Tom's Overall Verb Error Type Frequencies**



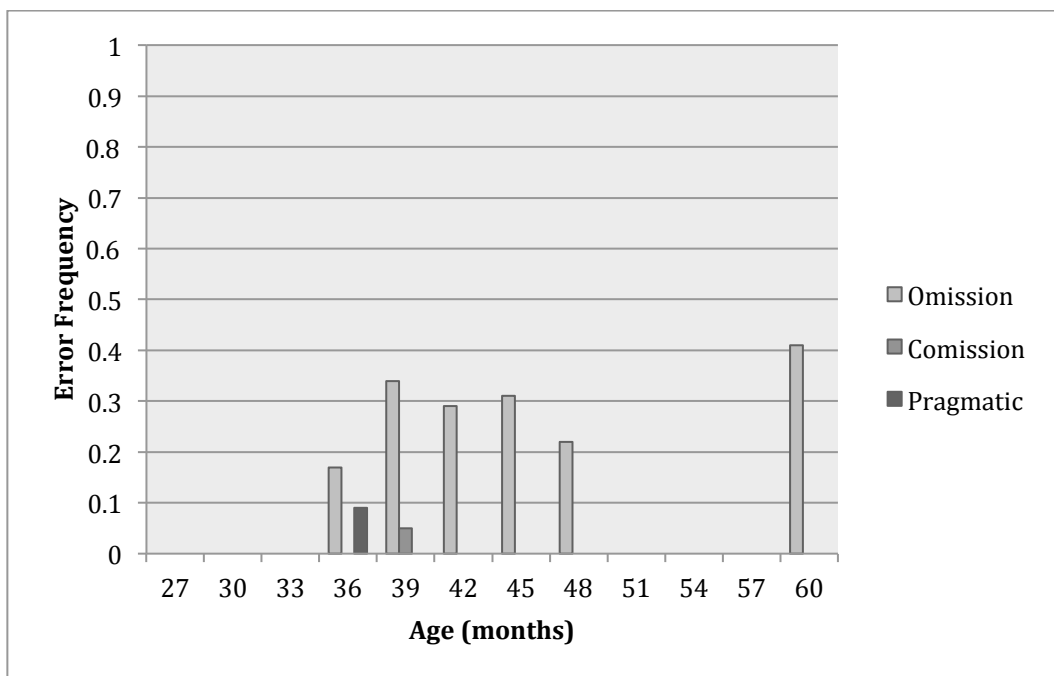
**Figure B.5: Lex's Overall Plural Error Type Frequencies**



**Figure B.6: Tom's Overall Plural Error Type Frequencies**



**Figure B.7: Lex's Overall Determiner Error Type Frequencies**



**Figure B.8: Tom's Overall Determiner Error Type Frequencies**

## Appendix C: Deaf Bimodal Bilinguals with CIs' Error Type Frequency Figures

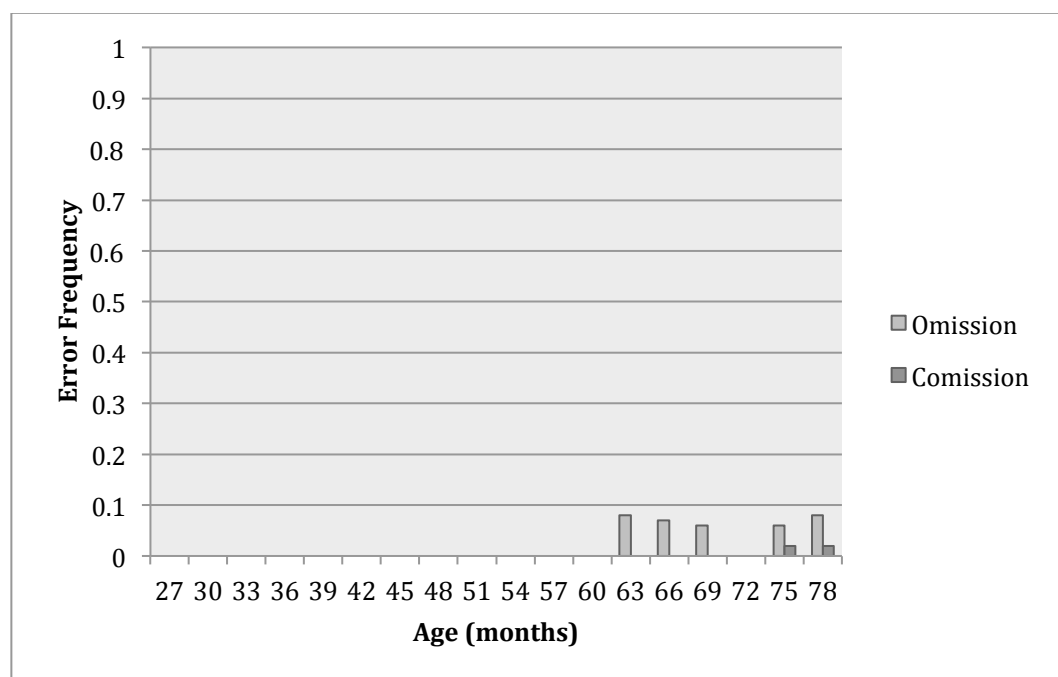
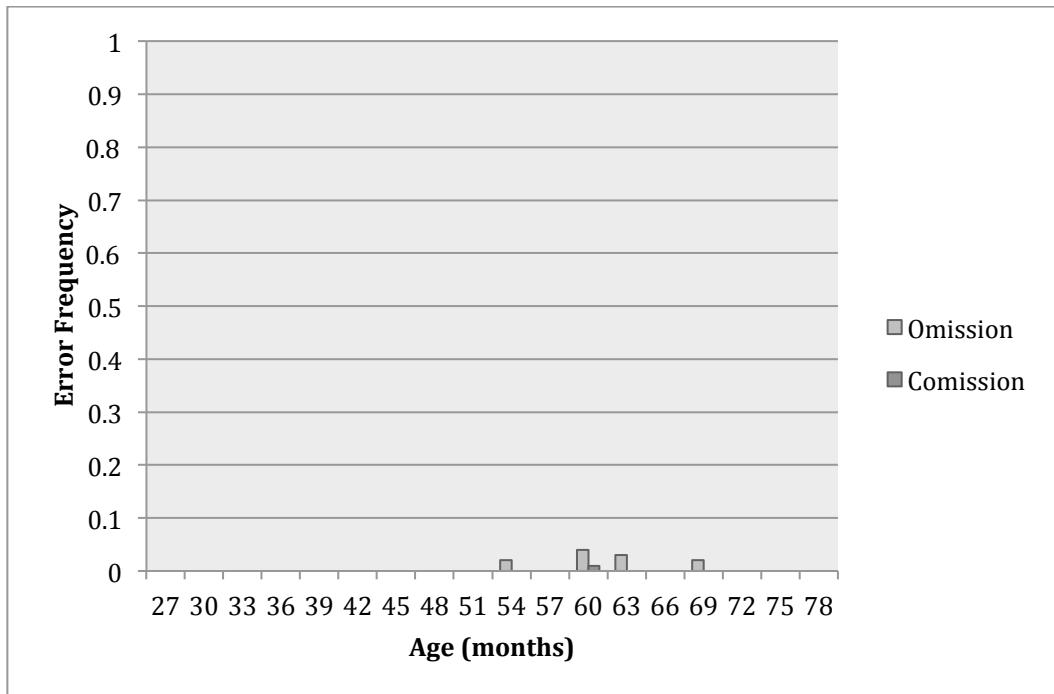
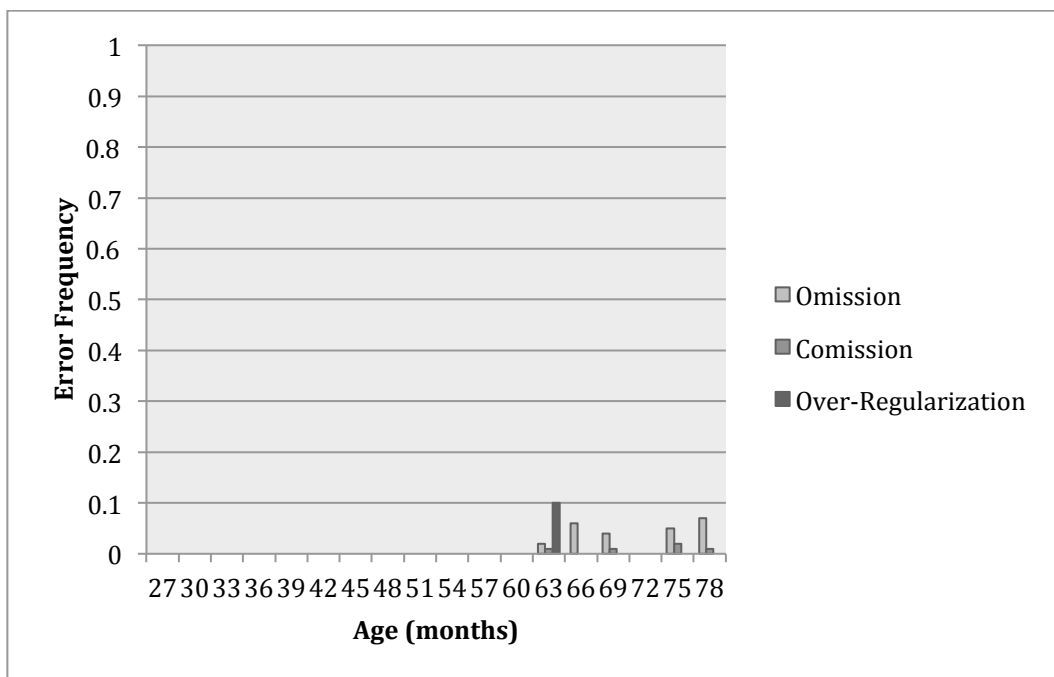


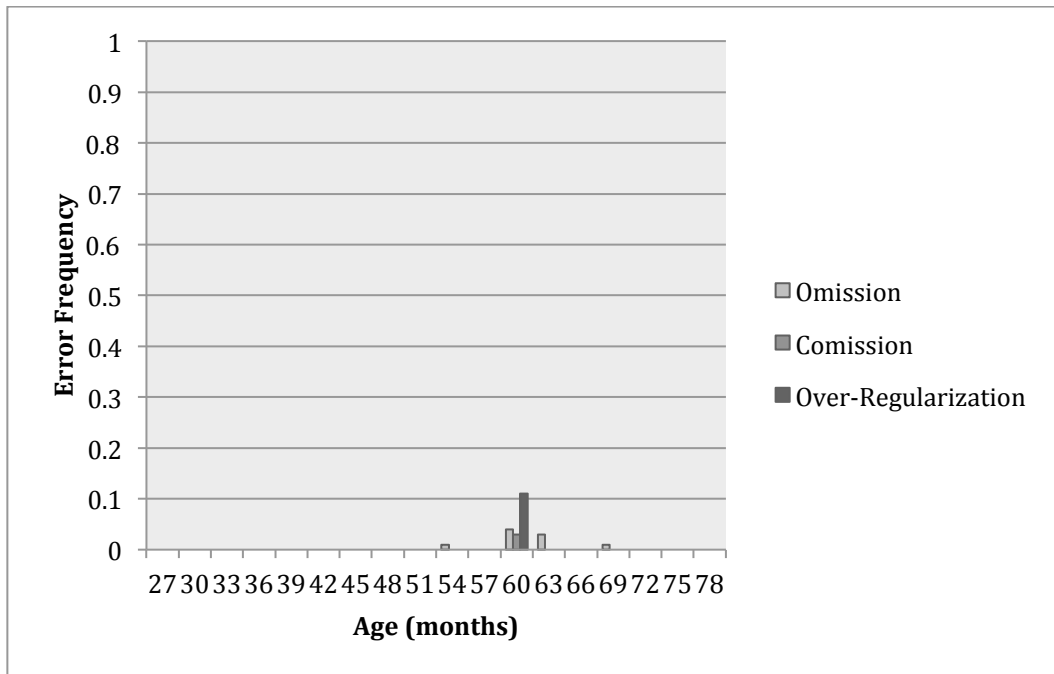
Figure C.1: Gia's Overall Error Type Frequencies



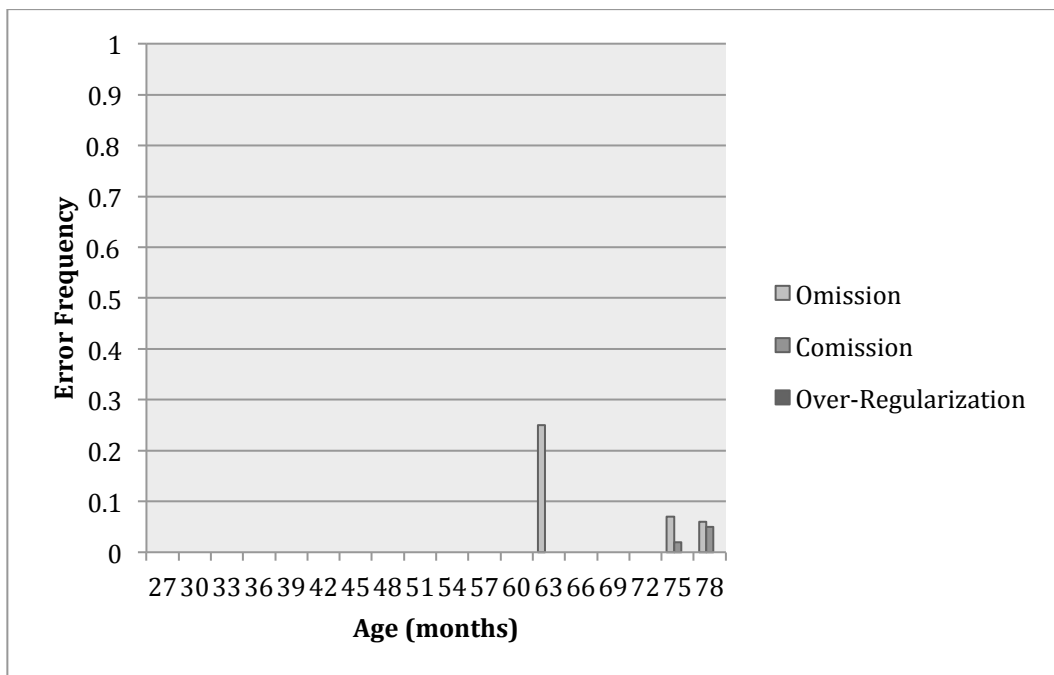
**Figure C.2: Nik's Overall Error Type Frequencies**



**Figure C.3: Gia's Overall Verb Error Type Frequencies**

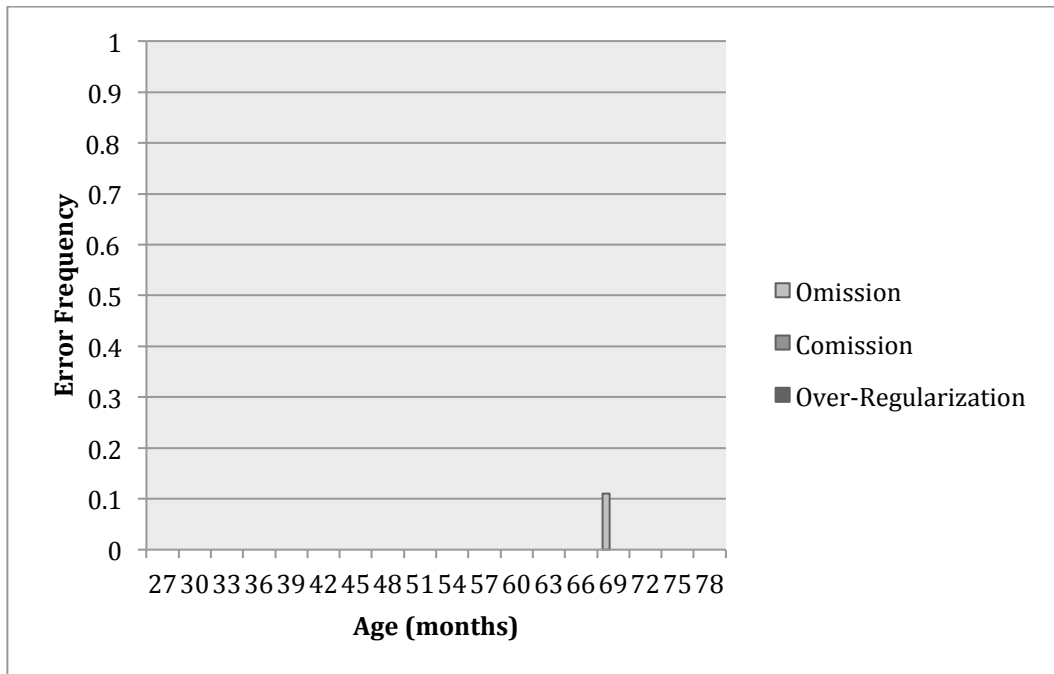


**Figure C.4: Nik's Overall Verb Error Type Frequencies**

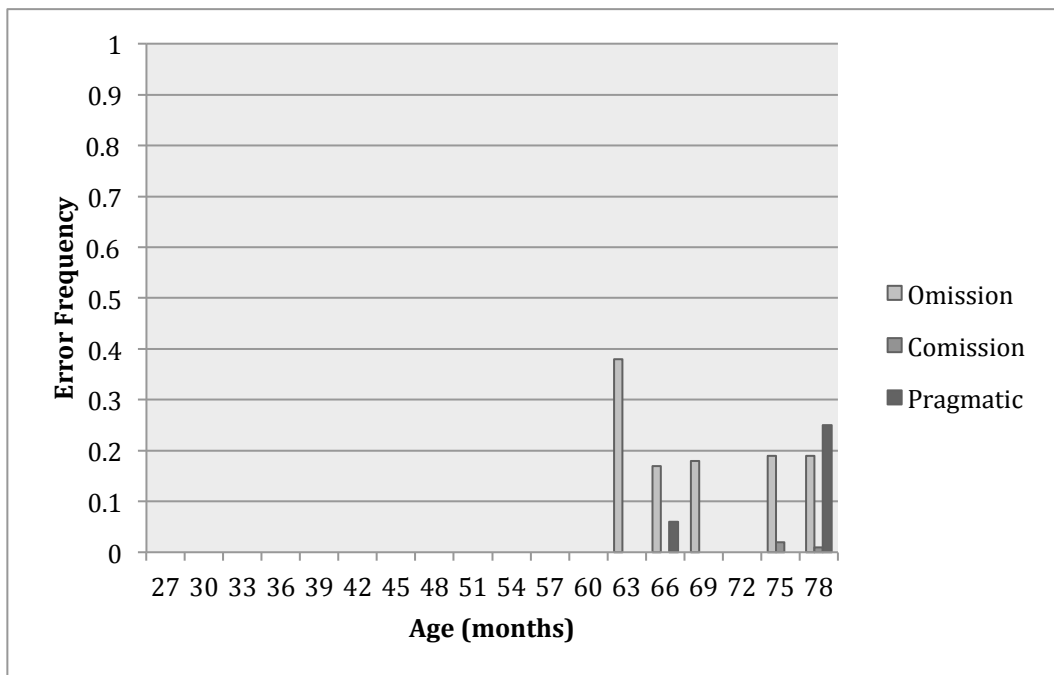


**Figure C.5: Gia's Overall Plural Error Type Frequencies**

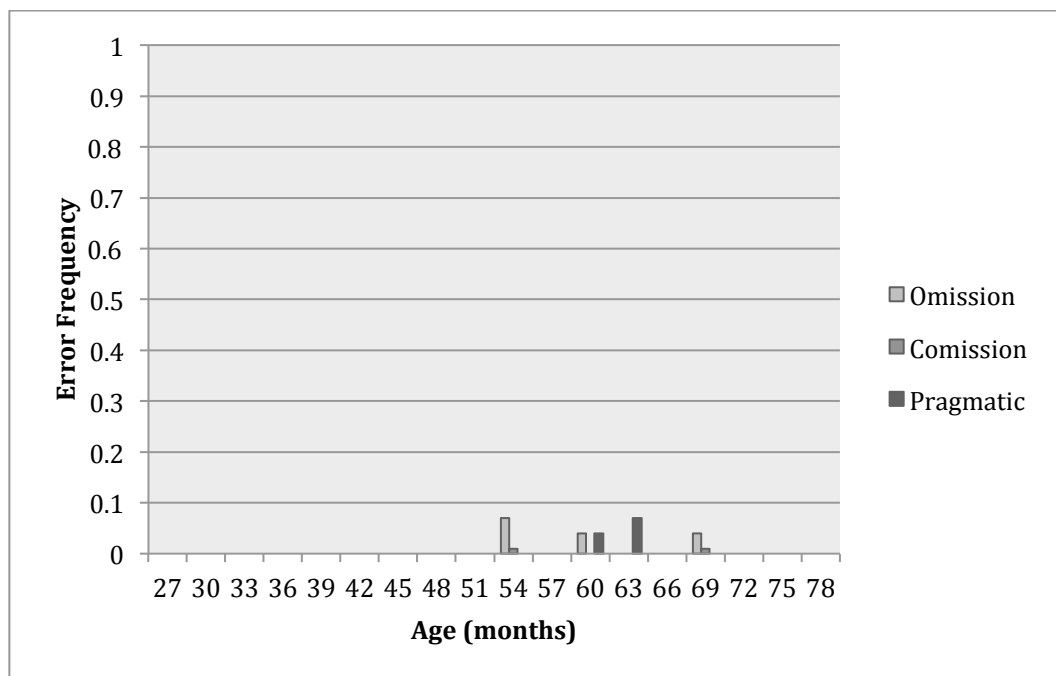




**Figure C.6: Nik's Overall Plural Error Type Frequencies**



**Figure C.7: Gia's Overall Determiner Error Type Frequencies**



**Figure C.8: Nik's Overall Determiner Error Type Frequencies**

## Appendix D: Verbal Morphology Cards

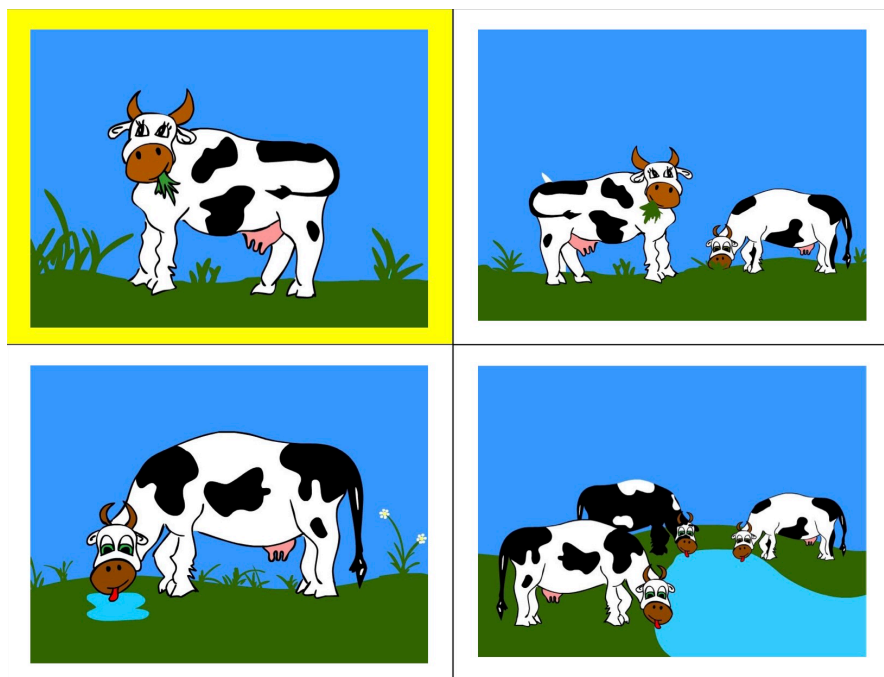


Figure D.1: A cow is eating grass.

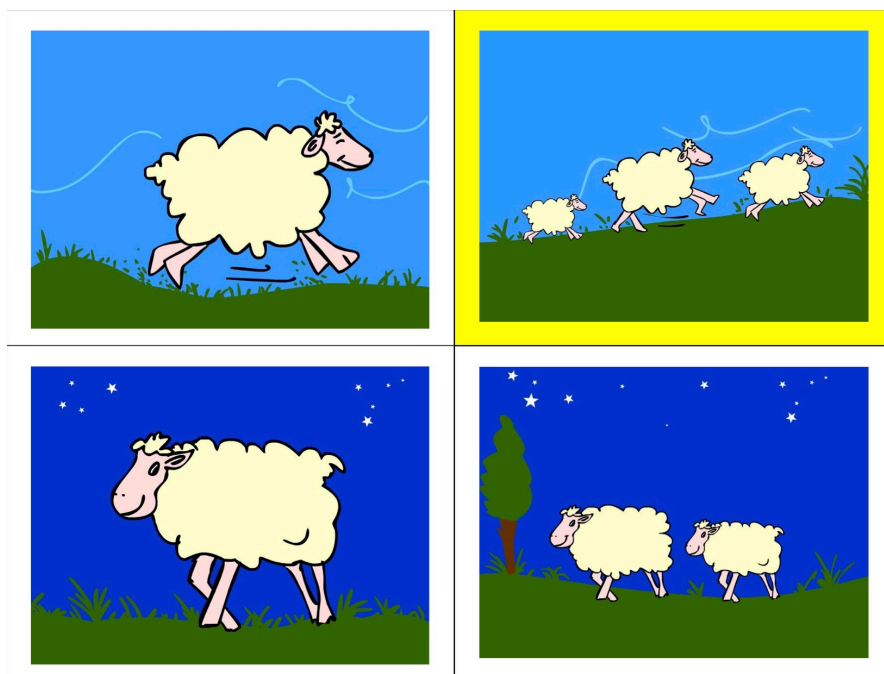
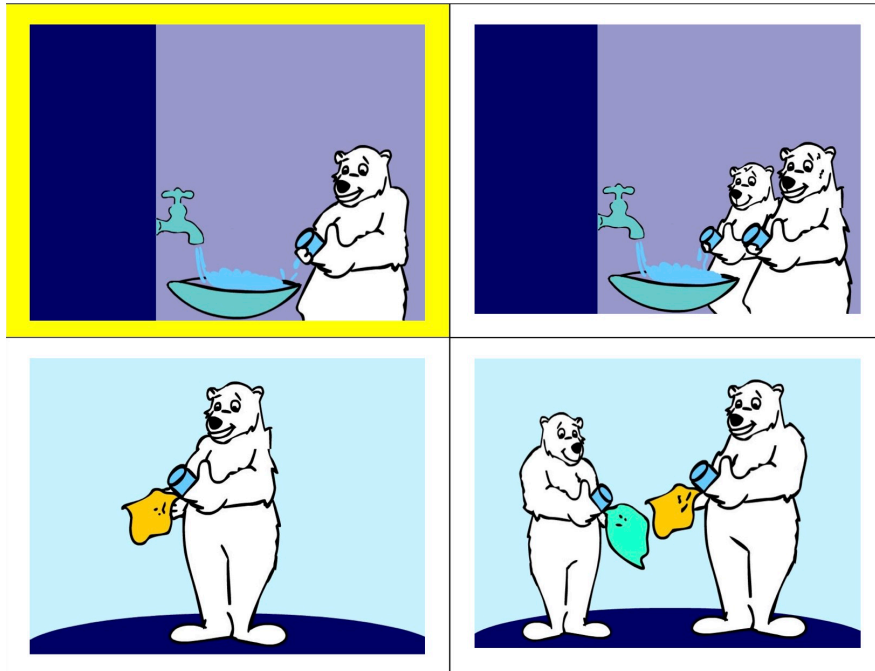
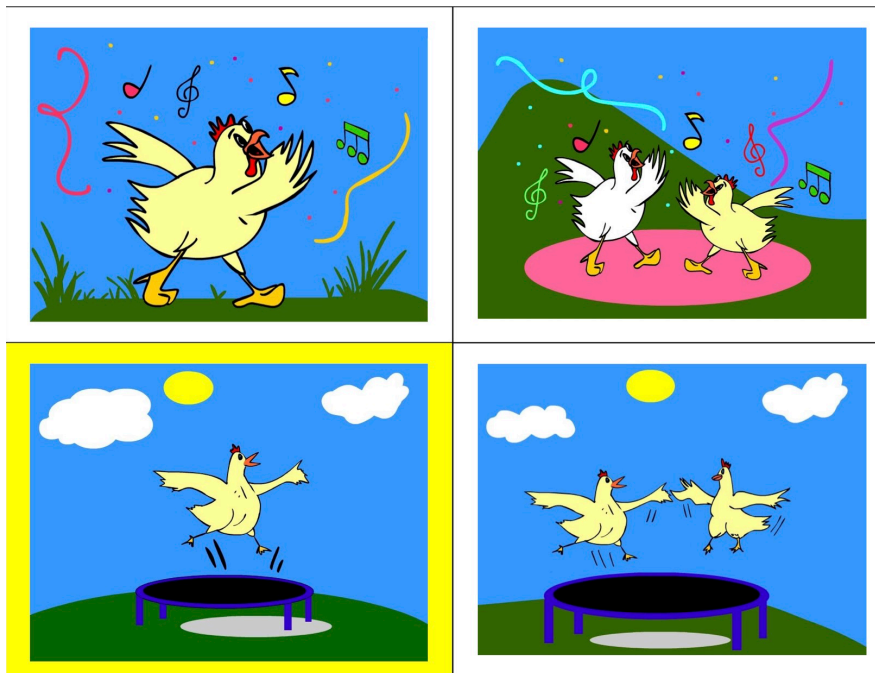


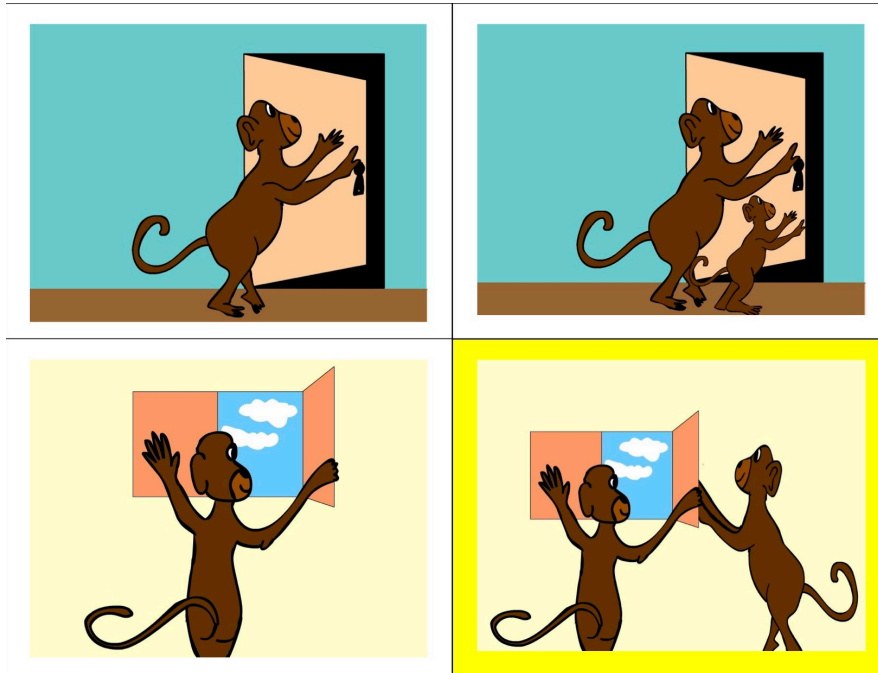
Figure D.2: Three sheep are running.



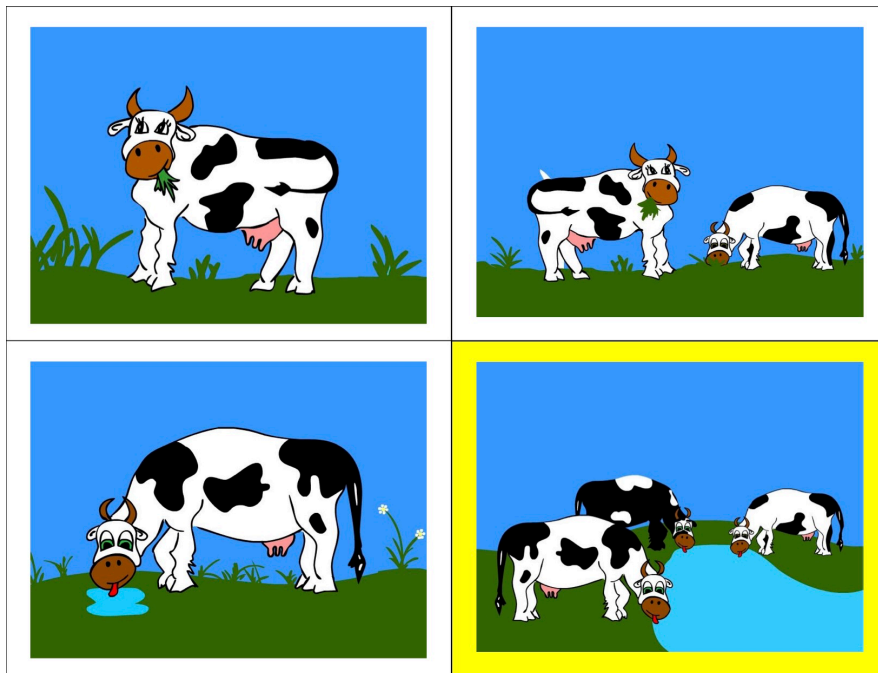
**Figure D.3: A polar bear is washing a cup.**



**Figure D.4: A chicken is jumping on a trampoline.**



**Figure D.5: Two monkeys are opening a window.**



**Figure D.6: Three cows are drinking water.**

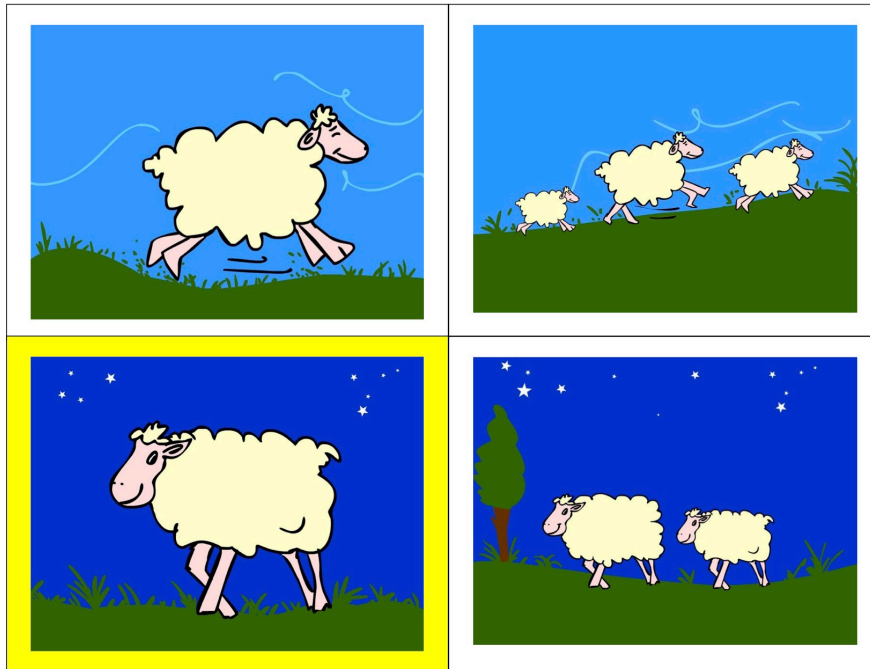


Figure D.7: A sheep is walking.

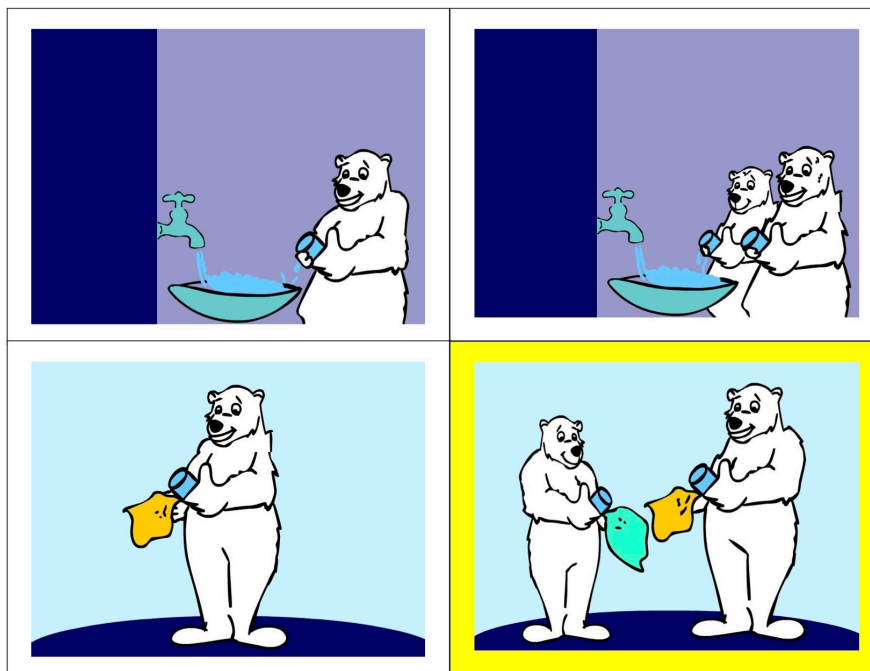


Figure D.8: Two bears are drying cups.



Figure D.9: Two chickens are dancing.

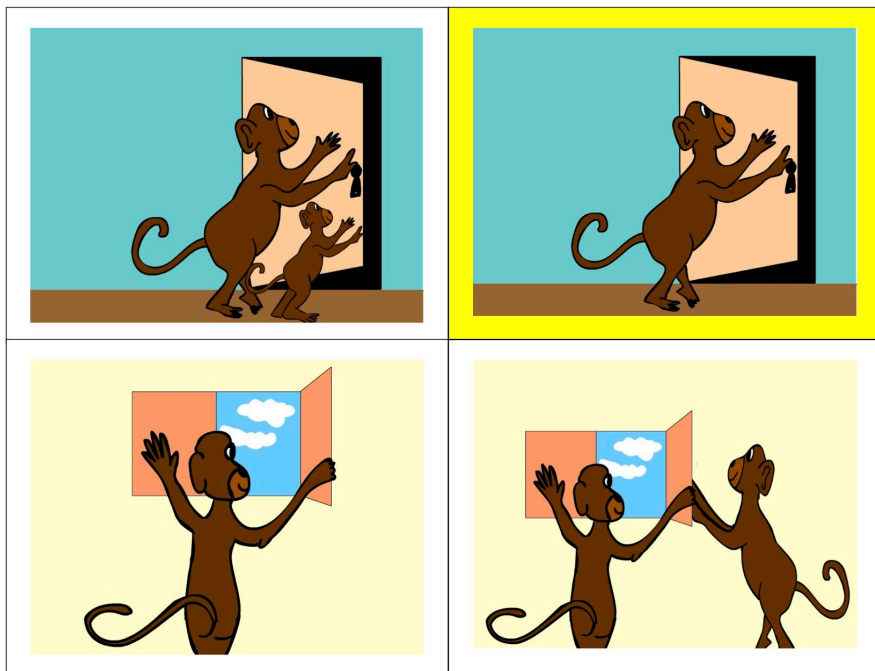


Figure D.10: A monkey is opening a door.

## Appendix E: Narrative Pictures



Figure E.1: Woman shopping.



Figure E.2: Men with vegetables.

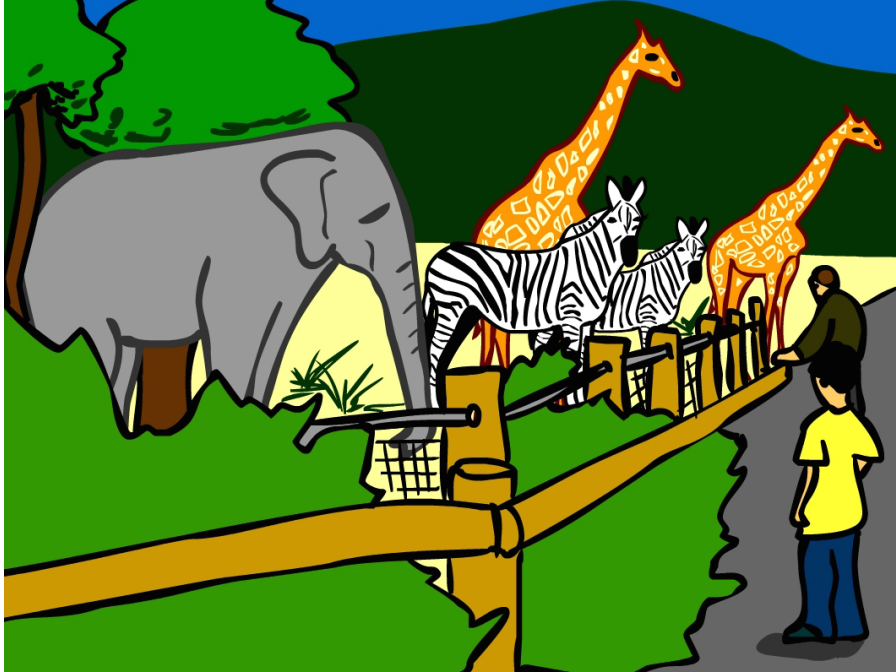




**Figure E.3: Child's birthday party.**



**Figure E.4: Carnival.**



**Figure E.5: Zoo.**



**Figure E.6: Classroom.**

## References

- Akhtar, N., Jipson, J. & Callanan, M. A. (2001), Learning words through overhearing. *Child Development*, 72(2), 416-430.
- Anderson, I., Weichbold, V., D’Haese, Patrick S. C., Szuchnik, J., Sainz Quevedo, M., Martin, J., Dieler, Wafaa Shehata & Phillips, Lucy. (2004). Cochlear implantation in children under the age of two – what do the outcomes show us? *International Journal of Pediatric Otorhinolaryngology*, 68, 425-431.
- Archbold, S. M., Nikolopoulos, T. P., Tait, M. O’Donoghue, G.M., Lutman, M.E. & Gregory, S. (2000) Approach to communication, speech perception and intelligibility after paediatric cochlear implantation. *British Journal of Audiology*, 34, 257-264.
- Barnard, J. M., Fisher, L. M., Johnson, K. C., Eisenberg, L. S., Wang, N., Quittner, A. L., Carson, C. M., Niparko, J. K. & The CDaCI Investigative Team (2015). A prospective longitudinal study of U.S. children unable to achieve open-set speech recognition 5 years after cochlear implantation. *Otology & Neurotology*, 36(6), 985-992.
- Baynton, D. C. (1998). *Forbidden signs: American culture and the campaign against sign language*. Chicago: University of Chicago Press.
- Bialystok, E., Luk, G., Peets, K. & Yang, S. (2010). Receptive vocabulary differences in monolingual and bilingual children. *Bilingualism: Language and Cognition*, 13, 525-531.
- Boons, T., Brokx, J. P. L., Dhooge, I., Frijns, J. H. M., Peeraer, L. Vermeulen, A., Wouters, J. & van Wieringen, A. (2012). Predictors of spoken language development following pediatric cochlear implantation. *Ear & Hearing*, 33(5), 627-639.
- Boons, T., De Raeve, L., Langereis, M., Peeraer, L., Wouters, J., van Wieringen, A. (2013). Expressive vocabulary, morphology, syntax, and narrative skills in profoundly deaf children after early cochlear implantation. *Research in Developmental Disabilities*, 34, 2008-2022.
- Bouchard, M., Ouellet, C., Cohen, H. (2009). Speech development in prelingually deaf children with cochlear implants. *Language and Linguistics Compass*, 3(1), 1-18.
- Brackenbury, T., Ryan, T. & Messenheimer, T. (2005). Incidental word learning in a hearing child of deaf adults. *Journal of Deaf Studies and Deaf Education*, 11(1), 76-93.
- Brown, R. (1973). *A first language: The early stages*. London: George Allen & Unwin.
- Buchman, C. A., Dillon, M. T., King, E. R., Adunka, M. C., Adunka, O. F. & Pillsbury, H. C. (2014). Influence of cochlear implant insertion depth on performance: A prospective randomized trial. *Otology & Neurotology*, 35(10), 1773-1779.

- Bunta, F. & Douglas, M. (2013). The effects of dual-language support on the language skills of bilingual children with hearing loss who use listening devices relative to their monolingual peers. *Language, Speech, and Hearing Services in Schools*, 44, 281-290.
- Byers-Heinlein, K., Burns, T. & Werker, J. (2010). The roots of bilingualism in newborns. *Psychological Science*, 21 343-348.
- Cantone, K., & Müller, N. (2005). Codeswitching at the interface of language-specific lexicons and the computational system. *International Journal of Bilingualism* 9 (2), 205-225.
- Carter, Allyson K., Dillon, Caitlin M & Pisoni, David P. (2002). Imitation of nonwords by hearing impaired children with cochlear implants: suprasegmental analyses. *Clinical Linguistics & Phonetics*, 16(8), 619-638.
- Caselli, M. C., Rinadli, P., Varuzza, C., Giuliani, A. & Burdo, S. (2012). Cochlear implant in the second year of life: lexical and grammatical outcomes. *Journal of Speech, Language, and Hearing Research*, 55, 382-394.
- Chen Pichler, D., Hochgesang, J., Lillo-Martin, D. & Müller de Quadros, R. (2010). Conventions for sign and speech transcription in child bimodal bilingual corpora. *Language, Interaction and Acquisition* 1.1, 11-40.
- Chen Pichler, D., Lee, J., & Lillo-Martin, D. (2014). Language Development in ASL-English Bimodal Bilinguals. In David Quinto-Pozos (Ed.), *Multilingual Aspects of Signed Language Communication and Disorder*, 235-260. Bristol, UK: Multilingual Matters
- Colletti, L., Mandalà, M. & Colletti, V. (2012). Cochlear implants in children younger than 6 months. *Otolaryngology – Head and Neck Surgery*, 147(1), 139-146.
- Cruz, I., Quittner, A. L., Marker, C. & DesJardin, J. L. (2013). Identification of effective strategies to promote language in deaf children with cochlear implants. *Child Development*, 84(2), 543-559.
- Cullington, H., Hodges, A. V., Butts, S. L., Dolan-Ash, S., & Balkany, T. J. (2000). Comparison of language ability in children with cochlear implants placed in oral and total communication educational settings. *The Annals of Otology, Rhinology, & Laryngology*, 185, 121-123.
- Dale, P., Dionne, G., Eley, T. & Plomin, R. (2000). Lexical and grammatical development: A behavioural genetic perspective. *Journal of Child Language*, 27, 619-642.
- Davidson, K., Goodwin, C., & Lillo-Martin, D. (2013, July). *Language transfer in ASL/English bimodal bilingual children with CIs*. Presentation at Theoretical Issues in Sign Language Research 11, London, England.

- Davidson, K., Lillo-Martin, D., & Chen Pichler, D. (2014). Spoken English language development in native signing children with cochlear implants. *Journal of Deaf Studies and Deaf Education*, 19(2), 238-250. doi:10.1093/deafed/ent045
- De Houwer, A. (1995). Bilingual language acquisition. In P. Fletcher & B. MacWhinner (Eds.), *The Handbook of Child Language*, (pp. 219-250. Oxford: Blackwell.
- De Villiers, J. G. & de Villiers, P. A. (1985). The acquisition of English. In Dan Isaac Slobin (Ed), *The Crosslinguistic Study of Language Acquisition Volume 1: The Data* (pp 27-139). Hillsdale, New Jersey: Lawrence Erlbaum Associates, Inc.
- Deriaz, M., Pelizzone, M. & Pérez Fornos, A. (2014). Simultaneous development of 2 oral languages by child cochlear implant recipients. *Otology & Neurotology*, 35, 1541-1544.
- Dettman, S. J., Pinder, D., Briggs, R. J. S., Dowell, R. C. & Leigh, J. R. (2007). Communication development in children who receive the cochlear implant younger than 12 months: risks versus benefits. *Ear & Hearing*, 28 (2) Supplement, 11S-18S.
- Dillon, C. M., Burkholder, R. A., Cleary, M. & Pisoni, D. P. (2004). Nonword repetition by children with cochlear implants: accuracy ratings from normal-hearing listeners. *Journal of Speech, Language, and Hearing Research*, 47, 1103-1116.
- Dillon, C. M., Cleary, M., Pisoni, D. B. & Carter, A. K. (2004). Imitation of nonwords by hearing-impaired children with cochlear implants: segmental analyses. *Clinical Linguistics & Phonetics*, 18(1), 39-55.
- Dionne, G., Dale, P. S., Boivin, M., Plomin, R. (2003) Genetic evidence for bidirectional effects of early lexical and grammatical development. *Child Development*, 74, 394-412.
- Dodds, A. Tyszkiewicz, E & Ramsden, R. (1997). Cochlear implantation after bacterial meningitis: The dangers of delay. *Archives of Diseases in Childhood*, 76, 139-140.
- Döpke, S (1998). Competing language structure: The acquisition of verb placement by bilingual German–English children. *Journal of Child Language*, 25, 555–584.
- Duchesne, L., Sutton, A. & Bergeron, F. (2009). Language achievement in children who received cochlear implants between 1 and 2 years of age: group trends and individual patterns. *Journal of Deaf Studies and Deaf Education*, 14(4), 465-485.
- Dunn, C. C., Walker, E. A., Oleson, J., Kenworthy, M., van Voorst, T., Tomblin, J. B., Ji, H., Kirk, K. I., McMurray, B., Hanson, M. & Gantz, B. J. (2014). Longitudinal speech perception and language performance in pediatric cochlear implant users: The effect of age at implantation. *Ear & Hearing*, 35(2), 148-160.

- Edwards, L. & Anderson, S. (2014). The association between visual, nonverbal cognitive abilities and speech, phonological processing, vocabulary and reading outcomes in children with cochlear implants. *Ear & Hearing, 35*(3), 366-374.
- Emmorey, K., Borinstein, H. B., Thompson, R. & Gollan, T. H. (2008). Bimodal bilingualism. *Bilingualism: Language and Cognition, 11*(1), 43-61.
- Ertmer, D. J., Kloiber, D. T., Jung, J., Kirleis, K. C. & Bradford, D. (2012). Consonant production accuracy in young cochlear implant recipients: developmental sound classes and word position effects. *American Journal of Speech-Language Pathology, 21*, 342-353.
- Fabiano-Smith, L. & Barlow, J. (2010). Interaction in bilingual phonological acquisition: Evidence from honetic inventories. *International Journal of Bilingual Education and Bilingualism, 13*, 81-97.
- Fabiano-Smith, L. & Goldstein, B. (2010). Phonological acquisition in bilingual Spanish-English speaking children. *Journal of Speech, Language, and Hearing Research, 53*, 160-178.
- Fagan, M. K. & Pisoni, D. B. (2012). Hearing experience and receptive vocabulary development in deaf children with cochlear implants. *Journal of Deaf Studies and Deaf Education, 15*(2), 149-161.
- Fennell, C., Byers-Heinlein, K. & Werker, J. (2007). Using speech sounds to guide word learning: The case of bilingual infants. *Child Development, 78*, 1510-1525.
- Flipsen, P. (2011). Examining speech sound acquisition for children with cochlear implants using the GFTA-2. *The Volta Review, 111*(1), 25-37.
- Geers, A. E. (2002). Factors affecting the development of speech, language, and literacy in children with early cochlear implantation. *Language, Speech, and Hearing Services in Schools, 33*, 172-183.
- Geers, A., Brenner, C. & Davidson, L. (2003). Factors associated with development of speech perception skills in children implanted by age five. *Ear & Hearing, 24 Supplement 1*, 24S-35S.
- Geers, A. E., Davidson, L. S., Uchanski, R. M. & Nicholas, J. G. (2013). Interdependence of linguistic and indexical speech perception skill in school-age children with early cochlear implantation. *Ear & Hearing, 34*(5), 562-574.
- Geers, A. E., Moog, J. S., Biedenstein, J., Brenner, C. & Hayes, H. (2009). Spoken language scores of children using cochlear implants compared to hearing age-mates at school entry. *Journal of Deaf Studies and Deaf Education, 14*(3), 371-385.

- Geers, A. E., Nicholas, J. G. & Sedey, A. L. (2003). Language skills of children with early cochlear implantation. *Ear & Hearing*, 24 Supplement 1, 46S-58S.
- Geers, A. E. & Sedey, A. L. (2010). Language and verbal reasoning skills in adolescents with 10 or more years of cochlear implant experience. *Ear & Hearing*, 32(1), 39S-48S.
- Genesee, F. & Nicoladis, E. (2007). Bilingual first language acquisition. In E. Hoff and M. Shatz (Eds.), *Handbook of Language Development* (pp. 324-342). Malden, MA: Blackwell Publishing.
- Gopnik, M. & Crago, M. B. (1991). Familial aggregation of a developmental language disorder. *Cognition*, 39, 1-50.
- Guiberson, M. M. (2005). Children with cochlear implants from bilingual families: Considerations for intervention and a case study. *The Volta Review*, 105(1), 29-39.
- Guo, L., Spencer, L. J., & Tomblin, B. (2013). Acquisition of tense marking in English-speaking children with cochlear implants: A longitudinal study. *Journal of Deaf Studies and Deaf Education*, 18(2), 187-205.
- Hammer, A. (2010). *The acquisition of verbal morphology in cochlear-implemented and specific language impaired children* (Doctoral dissertation). Universiteit Leiden, Netherlands.
- Hammer, A., Coene, M., Rooryck, J. & Govaerts, P. J. (2014). The production of Dutch finite verb morphology: A comparison between hearing-impaired CI children and specific language impaired children. *Lingua*, 139, 68-79.
- Hassanzadeh, S. (2012). Outcomes of cochlear implantation in deaf children of deaf parents: comparative study. *The Journal of Laryngology & Otology*, 126(10), 989-994.
- Henkin, Y., Taitelbaum-Swead, R., Hildesheimer, M., Mirigov, L., Kronenberg, J. & Kishon-Rabin, L. (2008). Is there a right cochlear implant advantage? *Otology & Neurotology*, 29(4), 489-494.
- Herzberg, O. (2010). *Early morphosyntactic and lexical development in young hearing impaired Hebrew-speaking children with cochlear implants compared to normally hearing peers*. (Doctoral Dissertation). Universiteit Antwerpen & Tel Aviv University.
- Hill, E. (1998). A dyspraxic deficit in specific language impairment and developmental coordination disorder? Evidence from hand and arm movements. *Developmental Medicine and Child Neurology*, 40, 388-395.
- Hoekstra, T., Hyams, N. (1998). Aspects of root infinitives. *Lingua*, 106, 81-112.

- Hoff, E. & Core, C. (2015). What clinicians need to know about bilingual development. *Seminars in Speech and Language, 36*(2), 89-99.
- Houston-Price, C., Caloghiris, Z. & Raviglione, E. (2010). Language experience shapes the development of the mutual exclusivity bias. *Infancy, 15*, 125-150.
- Huang, B. H. (2014). The effects of age on second language grammar and speech production. *Journal of Psycholinguistic Research, 43*, 397-420.
- Hudson Kam, C.L. & Newport, E. L. (2009). Getting it right by getting it wrong: When learners change languages. *Cognitive Psychology, 59*, 30-66.
- Humphries T., Kushalnagar, P., Mathur, G., Napoli, D. J., Padden, C., Rathman, C. & Smith, S. (2014). Bilingualism: A pearl to overcome certain perils of cochlear implants. *Journal of Medical Speech-Language Pathology, 21*(2), 107-125.
- Johnson, J. M., Watkins, R. V. & Rice, M. L. (1992). Bimodal bilingual language development in a hearing child of deaf parents. *Applied Psycholinguistics, 13*, 31-52.
- Jones, M. L. & Quigley, S. P. (1979). The acquisition of question formation in English and American Sign Language by two hearing children of deaf parents. *Journal of Speech and Hearing Disorders, 44*, 196-208.
- Kanto, L., Huttunen, K. & Laakso, M. (2013). Relationship between the linguistic environments and early bilingual language development of hearing children in deaf-parented families. *Journal of Deaf Studies and Deaf Education, 18*(2), 242-260.
- Klima, E., & Bellugi, U. (1979). *The signs of language*. Cambridge, Mass.: Harvard University Press.
- Koulidobrova, H. (2012). *When the quiet surfaces: 'Transfer' of argument omission in the speech of ASL-English bilinguals* (Doctoral dissertation). Retrieved from ProQuest Dissertations and Theses database. (UMI No. 3533882).
- Koulidobrova, H. (2016). Language interaction effects in bimodal bilingualism: Argument omission in the languages of hearing ASL-English bilinguals. *Linguistic Approaches to Bilingualism*. DOI 10.1075/lab.13047.kou
- Koulidobrova, H., Lillo-Martin, D., Quadros, R. M. de & Chen Pichler, D. (2011, June). Cross-language influence, code-switching, and code-blending. Paper presented at the International Symposium on Bilingualism 8, Oslo, Norway.
- Lahey, M., Liebergott, L., Chesnick, M., Menyuk, P., Adams, J. (1992). Variability in children's use of grammatical morphemes. *Applied Psycholinguistics, 13*(3), 373-398.



- Leonard, L. B. (1989). Language learnability and specific language impairment in children. *Applied Psycholinguistics*, 10, 179–202.
- Lieven, E., Behrens, H., Speares, J. & Tomasello, M. (2003). Early syntactic creativity: A usage based approach. *Journal of Child Language*, 30(2), 333-370.
- Lillo-Martin, D., Koulidobrova, H., Quadros, R. Müller de & Chen Pichler, D. (2012). Bilingual Language Synthesis: Evidence from WH-Questions in Bimodal Bilinguals. In Alia K. Biller, Esther Y. Chung, and Amelia E. Kimball (Eds.), *Proceedings of the 36th Annual Boston University Conference on Language Development*, 302-314. Somerville, MA: Cascadilla Press.
- Lillo-Martin, D., Quadros, R. M. de, Chen Pichler, D. & Fieldsteel, A. (2014) Language choice in bimodal bilingual development. *Frontiers in Psychology* 5, 1163 (Language Sciences Research Topic: Language by mouth and by hand).  
[<http://journal.frontiersin.org/Journal/10.3389/fpsyg.2014.01163/abstract>] doi: 10.3389/fpsyg.2014.01163
- MacLaughlin, D. (1997). The structure of determiner phrases: Evidence from American Sign Language (Doctoral dissertation). Retrieved from ProQuest.
- MacSwan, J. (2000). The architecture of the bilingual language faculty: Evidence from code-switching. *Bilingualism: Language and Cognition* 3 (1), 7-54.
- Marchman, V., Martínez-Sussman, C. & Dale, P. (2004). The language-specific nature of grammatical development: Evidence from bilingual language learners. *Developmental Science*, 7, 212-224.
- Marcus, G. F., Pinker, S., Ullman, M., Hollander, M., Rosen, T., J. & Xu, F. (1992). Overregularization in language acquisition. *Monographs of the Society for Research in Child Development*, 57(4).
- Markman, E. M., Wasow, J. L. & Hansen, M. B. (2003). Use of the mutual exclusivity assumption by young word learners. *Cognitive Psychology*, 47, 241–75.
- Marmor, G. & Petitto, L. (1979). Simultaneous communication in the classroom: How well is English grammar represented? *Sign Language Studies*, 23, 99-136.
- Mauldin, L. (2012). Parents of deaf children with cochlear implants: a study of technology and community. *Sociology of Health and Illness*, 34(4), 529-543.
- Mauldin, L. (2015). *Made to hear: Cochlear implants and raising deaf children*. Minneapolis, MI: University of Minnesota Press.

- May, B. J. & Niparko, J. K. (2009) Auditory Physiology and Perception. In J. K. Niparko (Ed), *Cochlear Implants: Principles & Practices* (pp. 1-18). Philadelphia, PA: Wolters Kluwer.
- Mayberry, R. I. (2010). Early Language Acquisition and Adult Language Ability: What Sign Language reveals about the Critical Period for Language. In M. Marschark & P. Spencer (Eds.), *Oxford Handbook of Deaf Studies, Language, and Education*, Volume 2, 281-291.
- McConkey Robbins, A., Green, J. E. & Waltzman, S. B. (2004). Bilingual oral language proficiency in children with cochlear implants. *Archives Otolaryngology – Head and Neck Surgery*, 130, 644-647.
- Miller, K. (2012). Not all children agree: Acquisition of agreement when input is variable. *Language Learning and Development*, 8, 255-277.
- Miller, K. and Schmitt, C. (2012). Variable input and the acquisition of plural morphology. *Language Acquisition*, 19, 223-261.
- Mitchell, R., & Karchmer, M. A. (2004). Chasing the mythical ten percent: Parental hearing status of deaf and hard of hearing students in the United States. *Sign Language Studies*, 4, 138–163.
- Mitchiner, J. & Sass-Lehrer, M. (2011). My child can have more choices: Reflections of Deaf mothers on cochlear implants for their children. In R. Paludneviciene & I. W. Leigh (Eds.), *Cochlear Implants: Evolving Perspectives* (pp. 71-94). Washington, DC: Gallaudet University Press.
- Morgan, G. P., Restrepo, M. A. & Auza, A. (2013). Comparison of Spanish morphology in monolingual and Spanish-English bilingual children with and without language impairment. *Bilingualism: Language and Cognition*, 16(3), 578-596.
- Murphy, J. & Slorach, N. (1983). The language development of pre-preschool hearing children of deaf parents. *British Journal of Disorders of Communication*, 18(2), 118-126.
- Nicholls, R. J., Eadie, P. A., & Reilly, S. (2011). Monolingual versus multilingual acquisition of English morphology: What can we expect at age 3? *International Journal of Language & Communication Disorders*, 46(4), 449-463.
- Nicoladis, E., Song, J. & Marentette, P. (2012). Do young bilinguals acquire past tense morphology like monolinguals only later? Evidence from French-English and Chinese-English Bilinguals. *Applied Psycholinguistics*, 33, 457-479.
- Nikolopoulos, T. P., Dyar, D., Archbold, S. & O'Donoghue, G. M. (2004). Development of spoken language grammar following cochlear implantation in prelingually deaf children. *Archives of Otolaryngology - Head and Neck Surgery*, 130, 629-633.

- Niparko, J. K., Tobey, E. A., Thal, D. J., Eisenberg, L. S., Wang, N., Quittner, A. L. & Fink, N. E. (2010). Spoken language development in children following cochlear implantation. *The Journal of the American Medical Association*, 303(15), 1498-1506.
- Nittrouer, S., Caldwell, A., Lowenstein, J. H., Tarr, E. & Holloman, C. (2012). Emergent literacy in kindergartners with cochlear implants. *Ear & Hearing*, 33(6), 683-697.
- Palmer, J. L. (2015). ASL word order development in bimodal bilingual children: Early syntax of hearing and cochlear-implanted Deaf children from signing families (Doctoral Dissertation). Gallaudet University, Washington, D.C.
- Paludneviciene, R. & Harris, R. L. (2011). Impact of cochlear implants on the Deaf community. In R. Paludneviciene & I. W. Leigh (Eds.), *Cochlear Implants: Evolving Perspectives* (pp. 3-19). Washington, DC: Gallaudet University Press.
- Paradis, J. (2006). Grammatical morphology in children learning English as a second language: Implications of similarities with specific language impairment. *Language, Speech, and Hearing Services in Schools*, 36, 172-187.
- Paradis, J. (2010). Bilingual children's acquisition of English verb morphology: Effects of language exposure, structure complexity, and task type. *Language Learning*, 60(3), 651-680.
- Paradis, J., Crago, M. & Genesee, F. (2006). Domain-general versus domain-specific accounts of Specific Language Impairment: Evidence from bilingual children's acquisition of object pronouns. *Language Acquisition*, 13(1), 33-62.
- Paradis, J., Nicoladis, E., Crago, M. and Genesee, F. (2011). Bilingual children's acquisition of the past tense: A usage-based approach. *Journal of Child Language*, 38, 554-578.
- Pearson, B. (2013). Distinguishing the bilingual as a late talker from the late talker who is bilingual. In L. A. Rescorla & P. S. Dale (Eds.), *Late Talkers: Language Development, Interventions and Outcomes* (pp 67-87). Baltimore: Brookes Publishing Co.
- Pearson, B., Fernández, S. & Oller, D. K. (1995). Cross-language synonyms in the lexicons of bilingual infants: One language or two? *Journal of Child Language*, 22, 345-368.
- Petitto, L. A., Katerlos, M., Levy, B. G., Gauna, K., Tétreault, K. & Ferraro, V. (2001). Bilingual signed and spoken language acquisition from birth: Implications for the mechanisms underlying early bilingual language acquisition. *Journal of Child Language*, 28, 453-496.
- Petroj, V. (2015). *Article distribution in the whispered speech of bimodal bilinguals* (unpublished generals examination paper). University of Connecticut, Storrs, CT.

- Petroj, V., Guerrero, K. & Davidson, K. (2014). ASL dominant code-blending in the whispering of bimodal bilingual children. In W. Orman & M. J. Valteau (Eds.), *Proceedings of the Boston University Conference on Language Development 38* (pp. 319-330), Cascadilla Press.
- Pierce, L. J, Genessee, F. & Paradis, J. (2013). Acquisition of English grammatical morphology by internationally adopted children from China. *Journal of Child Language*, 40(5), 1076-1090.
- Pine, J. M. & Lieven, E. V. M. (1997). Slot and frame patterns and the development of the determiner category. *Applied Psycholinguistics*, 18, 123-138.
- Pine, J. M., Conti-Ramsden, G., Joseph, K. L., Lieven, E. V. M., & Serratrice L. (2008). Tense over time: testing the Agreement/Tense Omission Model as an account of the pattern of tense-marking provision in early child English. *Journal of Child Language*, 35, 55-75.
- Pizer, G. (2008). *Sign and Speech in Family Interaction: Language Choices of Deaf Parents and their Hearing Children*. Ph.D. dissertation, University of Texas, Austin.
- Plack, C. J. (2005). *The sense of hearing*. New York, NY: Psychology Press.
- Preisler, G., Ahlström, M., Tvingstedt, A. (1997). The development of communication and language in deaf preschool children with cochlear implants. *International Journal of Pediatric Otorhinolaryngology*, 41, 263-272.
- Quadros, R. M. de, Chen Pichler, D., Lillo-Martin, D., Cruz, C. R., Kozak, L. V., Palmer, J. L., Pizzio, A. L. & Reynolds, W. (2015). Methods in Bimodal Bilingualism Research: Experimental Studies. In Orifanidou, E., Woll, B. & Morgan, G. (Eds.), *Research Methods in Sign Language Studies: A Practical Guide* (pp 251-275), John Wiley & Sons, Inc.
- Quadros, R. M. de & Lillo-Martin, D. (2007). Gesture and the acquisition of verb agreement in sign languages. In Heather Caunt-Nulton, Samantha Kulatilake, and I-Hao Woo (Eds.), *Proceedings of the 31st Annual Boston University Conference on Language Development*, 520-531. Somerville, MA: Cascadilla Press.
- Quadros, R. M. de, Lillo-Martin, D. & Chen Pichler, D. (2012). Bi-National Bi-modal Bi-Lingual Corpora of Child Language. In Heliana Mello, Massimo Pettorino & Raso Tommaso (Eds.), *Proceedings of the VIIth GSCP (Gruppo di Studi sulla Comunicazione Parlata) International Conference: Speech and Corpora*, 87-92. Firenze: Firenze University Press.
- Quadros, R. M. de, Lillo-Martin, D., Koulidobrova, H. & Chen Pichler, D. (2013). Noun Phrases in Koda Bimodal Bilingual Acquisition. *Theoretical Issues in Sign Language Research (TISLR)* 11; London, UK; July 2013.

- Redmond, S. M. (2005). Differentiating SLI from ADHD using children's sentence recall and production of past tense morphology. *Clinical Linguistics and Phonetics* 19, 109-127.
- Rice, M. L., Wexler, K. & Cleave, P. L. (1995). Specific Language Impairment as a Period of Extend Optional Infinitive. *Journal of Speech and Hearing Research*, 38, 850-863.
- Rice, M. L., & Wexler, K.. (1996). Toward tense as a clinical marker of specific language impairment in English-speaking children. *Journal of Speech and Hearing Research*, 39(6), 1239-1257.
- Rice, M. L., Wexler, K., & Hershberger, S. (1998). Tense over time: The longitudinal course of tense acquisition in children with specific language impairment. *Journal of Speech, Language, and Hearing Research*, 41(6), 1412-1431.
- Ruder, C. C. (2004). Grammatical morpheme developme in young cochlear implant users. *International Congress Series*, 1273, 320-323.
- Schiff, N. B. (1979). The influence of deviant maternal input on the development of language during the preschool years. *Journal of Speech and Hearing Research*, 22, 581-603.
- Schiff, N. B. & Ventry, I. M. (1976). Communication problems in hearing children of deaf parents. *Journal of Speech and Hearing Disorders*, XLI, 348-358.
- Serratrice, L. (2013). The Bilingual Child. In, Bhatia, T. K. & Ritchie, W. C. (Eds), *The Handbook of Bilingualism and Multilingualism*. Blackwell Publishing Ltd.
- Serratrice, L., Sorace, A. & Paoli, S. (2004). Crosslinguistic influence at the syntax-pragmatics interface: Subjects and objects in English-Italian bilingual and monolingual acquisition. *Bilingualism: Language and Cognition*, 7, 183-205.
- Sharma, A., Nash, A. A., & Dorman, M. (2009). Cortical development, plasticity and re-organization in children with cochlear implants. *Journal of Communication Disorders*, 42, 272-279.
- Smith, J., Durham, M. Fortune, L. (2007). "Mam, my trousers is fa'in doon!": Community, caregiver, and child in the acquisition of variation in a Scottish dialect. *Language Variation and Change*, 19, 63-99.
- Snyder, W. (2007) *Child Language: The Parametric Approach*. Oxford, UK: Oxford University Press.

- Spaepen, E., Coppola, M., Spelke, E., Carey, S., and Goldin-Meadow, S. (2011). Number without a language model. *Proceedings of the National Academy of Sciences*, 108(8): 3163-3168.
- Spencer, P. E. (2004). Individual differences in language performance after cochlear implantation at one to three years of age: Child, family, and linguistic factors. *Journal of Deaf Studies and Deaf Education*, 9(4), 395-412.
- Spencer, L. J. & Guo, L. (2013). Consonant development in pediatric cochlear implant users who were implanted before 30 months of age. *Journal of Deaf Studies and Deaf Education*, 18(1), 93-109.
- Sundara, M., Polka, L. & Molnar, M. (2008). Development of coronal stop perception: Bilingual infants keep pace with their monolingual peers. *Cognition*, 108, 232-242.
- Suskind, D. L., Leffel, K. R., Graf, E., Hernandez, M. W., Gunderson, E. A., Sapolich, S. G., Suskind, E., Leininger, L., Goldin-Meadow, S. & Levine, S. C. (2015). A parent-directed language intervention for children of low socioeconomic status: A randomized controlled pilot study. *Journal of Child Language*, 43(2), 366-406.  
doi:10.1017/S0305000915000033.
- Svirsky, M. A., Robbins, A. M., Kirk, K. I., Pisoni, D. B & Miyamoto, R. T. (2000). Language development in profoundly deaf children with cochlear implants. *Psychological Science*, 11(2), 153-158.
- Svirsky, M., Stallings, L., Lento, C. Ying, E., & Leonard, L. (2002). Grammatical morphological development in pediatric cochlear implant users may be affected by the perceptual prominence of the relevant markers. *Annals of Otology, Rhinology & Laryngology*, 111, 109-112.
- Svirsky, M. A., Teoh, S. & Neuburger, H. (2004). Development of language and speech perception in congenitally, profoundly deaf children as a function of age at cochlear implantation. *Audiology & Neuro-Otology*, 9, 224-233.
- Swanwick, R. & Tsverik, I. (2007) The role of sign language for deaf children with cochlear implants: Good practice in sign bilingual settings. *Deafness and Education International*, 9(4), 214-231.
- Szagan, G. (2004). Learning by ear: On the acquisition of case and gender marking by German-speaking children with normal hearing and cochlear implants. *Journal of Child Language*, 31, 1-30.
- Szagan, G. & Stumper, B. (2012). Age or Experience? The influence of age at implantation and social and linguistics environment on language development in children with cochlear implants. *Journal of Speech, Language, and Hearing Research*, 55 1640-1654.

- Szagun, G. & Schramm, S. A. (2016). Sources of variability in language development of children with cochlear implants: Age at implantation, parental language, and early features of children's language construction. *Journal of Child Language*, 43(3), 505-536.
- Teschendorf, M., Janeschik, S., Bagus, H., Lang, S. & Arweiler-Harbeck, D. (2011). Speech development after cochlear implantation in children from bilingual homes. *Otology & Neurotology*, 32, 229-235.
- Theakston, A. L., Lieven, E. V. M. & Tomasello, M. (2003). The role of input in the acquisition of third person singular verbs in English. *Journal of Speech, Language, and Hearing Research* 46, 863-877.
- Theakston, A. L. & Rowland, C. F. (2009). The acquisition of auxiliary syntax: A longitudinal elicitation study. Part 1: Auxiliary BE. *Journal of Speech, Language and Hearing Research*, 52, 1449-1470.
- Thomas, E., El-Kashlan, H. & Zwolan, T. A. (2008). Children with cochlear implants who live in monolingual and bilingual homes. *Otology & Neurotology*, 29, 230-234.
- Thordardottir, E. (2011). The relationship between bilingual exposure and vocabulary development. *International Journal of Bilingualism*, 15, 426-445.
- Thordardottir, E. (2014). The relationship between bilingual exposure and morphosyntactic development. *International Journal of Speech-Language Pathology; Early Online*, 1-18.
- Tobey, E. A., Thal, D., Niparko, J. K., Eisenberg, L. S., Quittner, A. L. & Wang, N. (2013). Influence of implantation age on school-age language performance in pediatric cochlear implant users. *International Journal of Audiology*, 52, 219-229.
- Unsworth, S. (2013). Current issues in multilingual first language acquisition. *Annual Review of Applied Linguistics*, 33, 21-50.
- Unsworth, S. (2015). Amount of exposure as a proxy for dominance in bilingual language acquisition. In Silva-Corvalan, C & Treffers-Daller, J. (Eds.) *Language dominance in bilinguals: Issues of measurement and operationalization*. Cambridge: Cambridge University Press
- Van den Bogaerde, B., & Baker, A. (2005). Code mixing in mother-child interaction in deaf families. *Sign Language & Linguistics*, 8, 153-176.
- Walker, E. A. & McGregor, K. K. (2013). Word learning processes in children with cochlear implants. *Journal of Speech, Language, and Hearing Research*, 56, 375-387.

- Waltzman, S. B., McConkey Robbins, A., Green, J. E. & Cohen, N. L. (2003). Second oral language capabilities in children with cochlear implants. *Otology & Neurotology*, 24, 757-763.
- Wexler, K. (1990). Optional infinitives, head movement and the economy of derivations in child grammar, *Society for Cognitive Science*. Cambridge, Massachusetts: MIT.
- Wexler, K. (1994). Optional infinitives, head movement and the economy of derivations. In D. Lightfoot & N. Hornstein (Eds.), *Verb movement* (pp. 305-362). Cambridge: England: Cambridge University Press.
- Wexler, K. (1998). Very early parameter setting and the unique checking constraint: A new explanation of the optional infinitive stage. *Lingua*, 106(1-4), 23-79.
- Wiefferink, C. H., Spaai, G. W. G., Uilenburg, N. & Vermeij, B. A. M. (2008). Influence of linguistic environment on children's language development: Flemish versus Dutch children. *Deafness and Education International*, 10(4), 226-243.
- Wilson, B. S. & Dorman, M. F. (2009) The Design of Cochlear Implants.. In J. K. Niparko (Ed), *Cochlear Implants: Principles & Practices* (pp. 95-135). Philadelphia, PA: Wolters Kluwer.
- Yehudai, N., Tzach, N., Shpak, T., Most, T. & Luntz, M. (2011). Demographic factors influencing educational placement of the hearing-impaired child with a cochlear implant. *Otology & Neurotology*, 32(6), 943-947.
- Yim, D. (2011). Spanish and English language performance in bilingual children with cochlear implants. *Otology & Neurotology*, 33, 20-25.
- Yip, V., & Matthews, S. (2007). *The bilingual child: Early development and language contact*. Cambridge, UK: Cambridge University Press.
- Yoshinaga-Itano, C., Baca, R. L. & Sedey, A. L. (2010). Describing the trajectory of language development in the presence of severe-to-profound hearing loss: A closer look at children with cochlear implants versus hearing aids. *Otology & Neurotology*, 31, 1268-1274.
- Young, G. A. & Killen, D. H. (2002). Receptive and expressive language skills of children with five years of experience using a cochlear implant. *Annals of Otology, Rhinology & Laryngology*, 111, 802-810.