2012

The role of linguistic input in shaping the conversational language of deaf preschoolers with a cochlear implant

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THE ROLE OF LINGUISTIC INPUT IN SHAPING THE CONVERSATIONAL LANGUAGE OF DEAF PRESCHOOLERS WITH A COCHLEAR IMPLANT

By

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An Independent Study
submitted in partial fulfillment of the requirements for the degree of:

Master of Science in Deaf Education

Washington University School of Medicine
Program in Audiology and Communication Sciences

May 18, 2012

Approved by:
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Abstract: This study investigates whether mothers who have children with cochlear implants fine-tune their own vocabulary and sentence complexity to that of their child. Whether and how fine-tuning leads to faster growth in these language skills is explored.

Acknowledgements

I would like to thank my advisor, Dr. Johanna Nicholas (Washington University, St. Louis, MO), for all of her dedication and support through the development of this project. Without her supervision this project would not have been possible. Additionally I would like to thank Sarah Fessenden and Christine Brenner from the Child Language Lab at Washington University in St. Louis: Sarah for her continuous encouragement and aid, and Christine for her expertise with statistical analysis. Portions of these data were supported by funding to the Child Language Laboratory at Washington University by The National Institutes of Deafness and Communication Disorders (Grant # R01DC004168).

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Abbreviations

1. Cochlear Implant (CI)
2. Number of Different Roots Words (NDRW)
3. Mean Length Utterance (MLU)
4. Number of Different Words (NDW)
5. Peabody Picture Vocabulary Test (PPVT)
6. Preschool Language Scale Third Edition (PLS-3)
7. Listening and Spoken Language (LSL)
8. Normal Hearing (NH)

INTRODUCTION

In the field of language acquisition research, "fine-tuning" refers to the adjustment of mothers' vocal and linguistic input to a child in relation to the child's own language level. Fine-tuning begins in infancy and the mother uses high pitch and lively intonation, which is a response to the infant's attention patterns (Snow, 1995). When the child begins to acquire words, the level of complexity in child-directed speech is adjusted in relation to the level of complexity of the child's own output and/or comprehension level (Snow, 1989). Cross (1977) found that mothers' discourse adjustments were more closely associated with measures of a child's psycholinguistic, linguistic and communicative abilities than with their chronological age. Fine-tuning also involves the idea that the optimal difference between the level of the mother's input to the child and the child's own language level is fairly small. It should be close enough that the child understands, at least to some extent, the meaning of the utterance, but large enough that novel structures and those not yet mastered by the child are modeled (Snow, 1989). Snow also stated that the mother's input should be structured in such a way that the child can hear what is correct, recognize what he is producing incorrectly, and in turn pick up on the higher language structures. Fine-tuning would necessarily lead to frequent changes in the mother's input as the child develops language. A simple example of fine-tuning by a mother to a nonverbal child would be when the child points to an object and the mother in turn labels the object. In labeling the object, the mother likely provides either a single word or phrase ("A ball!"). As the child's language grows he may produce an utterance such as "Mom, ball" in the same setting. The mother who is fine-tuning her language to this child may say, "Yes, that's a *red* ball."

<u>Fine-tuning of input to normally-hearing children</u>

Fine-tuning has been demonstrated to occur in mother-child dyads where the child is normally-hearing (NH). Murray, Johnson, and Peters (1990) tested the hypothesis that mothers adjust their language input to preverbal infants. This was determined by transcribing 3-minute videotaped sessions of mothers and their children at child's age 3, 6, and 9 months, and comparing their utterances. They established that in the second half of the 1st year of life (child's age 6-12 months), mothers begin to 'fine-tune' their utterances towards their children. It was also found that there are individual differences in fine-tuning within the mother-child pair. This leads to the question of *how* the mothers fine-tune and whether their fine-tuning is predicated upon the language abilities of their children. The same researchers also found that relatively simple input by the mother to the child leads to more advanced receptive language development for the child than if the input was very complex. In other words, if the mothers communicated at a level just above the child's ability to understand, this led to growth in the child's receptive language abilities. Cross (1977) also found similar results within a group of children developing language at a rapid rate. Recordings were made of play sessions between mothers and their children on at least three separate occasions. Utterances at different ages were analyzed and results showed that mothers' utterances become longer as their child's language became more linguistically sophisticated. It was reported that, on average, mothers' mean length utterance (MLU) was fewer than 3 morphemes longer than their child's, and less than half a morpheme longer than their child's longest utterance. This suggests that mothers have an ability to track, perhaps unconsciously, the child's language complexity and to adjust their own language to the optimal level for their child.

While Murray, Johnson, and Peters (1990) found that fine-tuning occurs with respect to grammatical complexity, Sokolov (1993) explored a fine-tuning hypothesis in the lexical domain. Using a local contingency analysis, this researcher examined the relationship of parent-to-child utterances to determine whether particular lexical classes were deleted or added by the mother while interacting with her child over time. He obtained multiple samples of interactions between parents and their children between the ages of 2-5 years. He was able to compare the language input of the parent to the output of the child at each particular interaction. It was determined that as the child developed language, the parents would delete or fill in the missing lexical item as necessary. While Sokolov's study demonstrated the existence of fine-tuning in his sample of dyads, due to a small sample size he could not conclusively state whether fine-tuning facilitates higher language ability. For the current study, we will explore the fine-tuning hypothesis as described by previous research, and determine whether it is practiced by mothers of deaf children with cochlear implants (CIs) who are learning spoken language. If so, we will investigate whether this practice leads to higher language abilities for the child.

Fine-tuning of input to children with hearing loss

There is a vast literature documenting that children who have a severe to profound hearing loss show delays in language acquisition even with good auditory-oral training and a young age of amplification. It has been found that those children who receive a cochlear implant (CI) at especially young ages experience faster language development than those who have the same hearing loss and also use hearing aids (Nicholas & Geers, 2006). It has also been found that children who receive an implant at 24 months or younger are more likely to achieve age-appropriate spoken language than those receiving an implant past this critical age (Nicholas & Geers, 2007). Against this backdrop of improving spoken language outcomes with advancing technology, clinical and educational researchers have been interested in discovering whether specific aspects of linguistic input to children with CIs will facilitate even faster language acquisition and development.

Maternal input to children with CIs was explored by DesJardin and Eisenberg (2007) when they investigated the relationship between maternal contributions and language skills in young children (mean age = 4.8 yrs.). The mothers and their children were videotaped and their language was analyzed based on a single session. It was found that mothers' facilitative language techniques were related to language outcome. For example, the use of higher-level recasts was positively associated with children's receptive language abilities, and the use of open-ended questions was positively related to the children's expressive language. They also found that the higher-level techniques are used more frequently as the child achieves a higher level of understanding. The authors also found that mother's MLU accounted for most of the variance in children's receptive and expressive language skills. From these findings, the authors suggest that the variability in language skills of children with CIs may be related to the influence of maternal linguistic input.

Dettman, Ramp, Holt, Dowell, and Courtenay (2011) analyzed the use of morphemes by mothers of deaf children with CIs in relation to mothers of children with normal hearing (NH) from age 1-8 years. In terms of MLU, the increase found within mothers of children with CIs did not parallel the increase in MLU of the mothers of children with NH. There was wide variation of MLU within mothers of children with hearing loss. These authors suggest that mothers of children with CIs are unsure about how to fine-tune their language to their hearing-impaired children; they do not know whether to fine-tune according to the child's hearing age, chronological age, or linguistic ability. This led to the conclusion that the children may be missing out on hearing important morphological aspects of language. The children may not be hearing appropriate and natural language models for morphological development and this could be a contributing factor in any language delay.

Use of fine-tuning by mothers of children with other communicative disabilities

Johnson-Glenberg and Chapman (2004) used similar measures in a fine-tuning study of young adolescents (ages 12-26) with Down syndrome and found no significant correlation between parent MLU and child MLU, but did find a positive correlation between parent NDW and child NDW suggesting that parents of children with Down Syndrome are moderately tuning their NDW to their children's NDW. It is unknown, of course, whether the nonverbal cognitive delays of children with Down Syndrome, not shared by the typical deaf child using CIs, contribute to these findings.

Purpose of the present study

The current study examines whether mothers of deaf children with CIs utilize fine-tuning in conversations with their child and, if so, whether there is a relationship between this fine-tuning at age 3.5 and the language produced by the child a year later. In order to consider growth in both the grammatical and lexical domains, we will look at the fine-tuning using both mean length utterance (MLU) as well as number of different root words (NDRW). It is hypothesized that children whose mothers produce language at a level just above the level of their child will have the fastest growth rates in that language domain when tested a year later.

METHOD

Participants

Participants in this study were 60 children with CIs (25 female, 35 male) and their mothers. The children were presumed deaf from birth and received a CI between 7-23.5 months of age. The mean age of first implantation was 16.15 months (SD = 4.64 months). Seven of the participants had bilateral CIs while the remaining 53 had only one CI. The children were recruited from oral deaf education programs and speech therapy practices from 24 different US states and Canada. The participants did not have developmental or medical conditions other than their hearing loss that would interfere with language and speech development. In order for children to participate in this study, it was determined that they did not have any other nonverbal learning deficits. This was determined either by tests previously administered by the school or by the administration of the Daily Living Skills and Motor domains of the Vineland Adaptive Behavior Scales (Sparrow, Balla & Cicchetti, 1984) by the study staff. The children recruited had families that spoke English as the primary or only language in the household. Forty of the children received an implant model from the Cochlear Corporation, 16 children had implants from the Advanced Bionics Corporation, and 4 children had a Med-El CI. The types of speech processors are shown in Table 1. The mother's education levels as well as the family's income category are represented in Table 2 and Table 3, respectively. The mothers' mean level of education was a bachelor's degree and the vast majority of the children came from families with total incomes at or above $90,000. These two characteristics make this sample of mothers and children relatively advantaged in comparison to the demographics of the average American family.

Procedure

The transcripts used in this study were derived from play sessions recorded for a large multi-year project. Each participant was videotaped in a 30-minute play session with his or her parent at 3.5 and again at 4.5. In 56 out of 60 families the parent participating in this study was the child's mother. The parent was asked to communicate with the child naturally, in a manner as they do when playing at home. There were four sets of toys presented, and a new set was introduced every 7-8 min. The purpose of these toys was to promote conversation.

Transcription

Transcription for both child and parent utterances utilized the CHAT format of the Child Language Data Exchange System (MacWhinney, 2000). After each transcription was initially completed, a second transcriber verified what had been recorded and added any words that had been missed or transcribed incorrectly.

Dependent Variables

MLU and NDRW were counted using the CLAN software programs provided by the Child Language Data Exchange System (MacWhinney, 2000). MLU and NDRW were calculated for both the child (as outcome variables) and the mother (as predictor variables). The Preschool Language Scale- Third Edition (Zimmerman, Steiner, & Pond, 1992) and Peabody Picture Vocabulary Test (PPVT-III; Dunn & Dunn, 1997) were administered to the children at age 4.5 years. The standardized scores from these tests were used together with the child's MLU and NDRW as outcome measures in the current study.

RESULTS

Mother-to-Child Fine-Tuning

The first step was to determine whether mothers fine-tuned to their child's language level, and this was done by calculating the ratio of mother NDRW to child NDRW at test age 3.5. This was done for each dyad by dividing the mother's NDRW by the child's NDRW. The result of this calculation for each dyad can be seen in Figure 1. For the NDRW, 29 of the dyads (48%) had a ratio between 1-2, 20 (33%) were between 2-3, 7 (12%) between 3-4, 3 (5%) between 4-5, and one dyad had a ratio above 6. While it initially appeared that this last dyad, an obvious outlier, might significantly skew the results, calculations including and excluding this dyad's scores showed that the correlations were largely unchanged, so this dyad's scores were included in subsequent analyses.

After ratios were calculated for NDRW, the same procedure was used to find the ratios for MLU. It was found that there was less variability in the MLU measure than in NDRW. Figure 2 displays the frequency of the ratios of MLU for each dyad. Thirty-six of the dyads (60%) had a ratio between 1-2, 20 (33%) had a ratio between 2-3, and 4 (7%) had a ratio between 3-4.

Relationship between matching and outcome levels achieved at 4.5

To determine how the ratio of mother to child NDRW and MLU relate to the outcome variables (child's NDRW, MLU, PPVT and PLS-3 scores at 4.5), Pearson correlations were calculated and are shown in Table 4. All of the correlations are negative, revealing that as the ratio of mother-to-child complexity increases, the child shows less language growth. Stated another way, as the mother matches her language more closely to the child at 3.5, the child shows improvement in that aspect of language at age 4.5 years. This relation holds for formal test scores as well.

In terms of grammar (MLU), it was also found that if the mother maintains a low ratio of MLU in relation to the child, the child is more likely to have a higher MLU at 4.5. These significant correlations help to support the idea that the more "in tune" the mother's input is in relation to the language level of the child, the higher the child will perform on language tasks one year later.

Figure 3 is a scatterplot with ratio of mother-to-child NDRW at 3.5 along the x-axis and child NDRW at age 4.5 along the y-axis. The trend line plotted displays the relationship between ratio and child NDRW at 4.5 and shows that as the ratio between mother and child NDRW at 3.5 increases, child NDRW at 4.5 decreases. A linear regression was done with mother-to-child NDRW ratio as the predictor and child NDRW at 4.5 as the outcome. The ratio of mother-to-child NDRW at child's age 3.5 years showed a moderate, negative correlation ($r = -.626$, $p < .05$) with child's age 4.5 NDRW. Linear regression demonstrated a significant relationship ($F (1,58) = 37.366$, $p < .001$) between these two variables, which explains about 39% of the variability in the children's NDRW at age 4.5. The standardized beta coefficient of -.626 shows that for every incremental *increase* in the ratio of mother-to-child NDRW, we see a corresponding .626 incremental *decrease* in child's 4.5 NDRW.

In order to explore whether the important factor was the mother's absolute *level* of input, as opposed to the ratio of input in comparison to the child, a second linear regression was done using simply the mother's NDRW 3.5 as the predictor and child NDRW at 4.5 as the outcome. Linear regression demonstrated a significant relationship ($F (1,58) = 17.95$, $p < .001$) between these two variables, which explains about 24% of the variability in child NDRW at 4.5. The standardized beta coefficient of .486 shows that for every incremental increase in mother's NDRW at 3.5, we see a corresponding .486 increase in child's NDRW at 4.5. This shows that while the absolute level of input is important, the ratio of mother-to-child vocabulary is a stronger predictor of the child's outcome a year later.

Figure 4 is a scatterplot with ratio of mother to child MLU at 3.5 along the x-axis and child MLU at age 4.5 along the y-axis. The trend line plotted displays the relationship between ratio and child MLU at 4.5: as the ratio between mother and child MLU at 3.5 increases, child MLU at 4.5 decreases. A linear regression was done with mother-to-child MLU ratio as the predictor and child MLU at 4.5 as the outcome. The ratio of mother-to-child MLU at child's age

3.5 years showed a moderate negative correlation (r = -.615, $p < .05$) with child's age 4.5 MLU. Linear regression demonstrated a significant relationship ($F(1,58) = 35.37$, $p < .001$) between these two variables, which explains about 38% of the variability in the children's MLU at age 4.5. The standardized beta coefficient of -.615 shows that for every incremental *increase* in the ratio of mother-to-child MLU, we see a corresponding .615 incremental *decrease* in child's 4.5 MLU.

Similarly to the vocabulary analyses, we explored whether the absolute value of the mother's MLU or the ratio was the better predictor. A linear regression was calculated with mother MLU 3.5 as the predictor and child MLU at 4.5 as the outcome. Linear regression demonstrated a significant relationship ($F(1,58) = 41.65$, $p < .001$) between these two variables, which explains about 42% of the variability in CH MLU at 4.5. The standardized beta coefficient of .647 shows that for every incremental increase in mother's MLU at 3.5, we see a corresponding .647 increase in child's MLU at 4.5. In this case, the ratio was found to be a slightly poorer predictor than the mother's MLU alone.

Relationship between matching and growth achieved between 3.5 and 4.5

In addition to using the child's language level (represented by NDRW, MLU, and formal test scores at 4.5) as outcome measures, it was also of interest to examine the amount of child's growth in NDRW and MLU between 3.5 and 4.5 as additional outcome measures. Table 5 provides the correlations of mother-child ratio to the growth in child's scores for both NDRW and MLU. Neither of these correlations was found to be significant.

It is proposed that the main reason the correlations between ratio and child growth are not significant is due to the fact that some children regressed from 3.5 to 4.5 in both NDRW and MLU. The scatterplots in Figures 5 and 6 display the fine-tuning ratios on the x-axis and the child's growth on the y-axis. The red line depicts a growth level of "0". The points below the red line in these scatterplots display the children that regressed from 3.5 to 4.5. Seven of the children regressed in NDRW from 3.5 to 4.5, and eight of the children regressed in MLU in the year. These scatterplots reveal moderately flat trend lines for both NDRW and MLU and the relationships of the ratios to the child's growth are not significant.

Figures 7 and 8 show child growth from 3.5 to 4.5 in NDRW and MLU respectively. Each line represents the growth in language skill of one of the children, and data from all 60 children are displayed on these graphs. From these figures, the change in one year can be grossly visualized. While most children improved on these measures, 12% regressed for NDRW, 13% regressed for MLU, and some children appear to be unchanged with a relatively flat growth curve.

DISCUSSION

The main questions of this study were whether mothers of deaf children with CIs utilize fine-tuning in conversations with their child and, if so, whether there is a relationship between this fine-tuning and subsequent language outcomes by the child a year later. The hypothesis was that children whose mothers produce language just above the language of their child will have the highest outcome scores and fastest growth rates in language when tested a year later.

When the ratio of mother-to-child NDRW and MLU were calculated, all the ratios for all the participants were positive, revealing that all mothers do in fact speak at a level above their children. Almost half of the mothers in this study produced ratios between 1.0-2.0 for both NDRW and MLU which means that for each word a child produced, the mother was producing 1-2 more words, or for each morphological marker or other element that increases utterance length the child was producing, the mother was in turn producing 1-2 more. The next most common ratio was between 2-3 and this pattern continued, with higher ratios occurring with much less frequency in this sample. This shows that the mothers were, indeed, fine-tuning rather closely to their child's language level.

The question of just how mothers fine-tune and how this relates to child language outcomes at 4.5 was further examined. Regression analysis helped reveal the nature of the relationship between this fine-tuning behavior and child outcome. The dyads with higher ratios (meaning that the mother produced a relatively greater amount than the child) had children who produced lower scores on the formal language tests (PPVT and PLS-3) as well as a lower number of NDRW and MLU. The hypotheses that (a) the mothers will fine-tune their utterances to the language level of their child and (b) that this fine-tuning will produce higher language in their child a year later were supported. This is consistent with past research on the fine-tuning hypothesis in hearing children (Murray, Johnson and Peters, 1990, Cross, 1977).

Another question in the current study was how mother input influences the child's rate of growth from 3.5 to 4.5. The correlation between mother-to-child ratio and *growth* in child's NDRW or MLU in a year was not significant. This seemingly surprising finding means that the amount of growth in the child was not related to any fine-tuning behavior on the part of the mother. We suspect this occurred because there were some children who showed poorer performance at age 4.5 than age 3.5. These results were not consistent with the hypothesis. Previous research has not used change in language (which simultaneously accounts for the child's starting point) as an outcome measure.

One possible alternative explanation for the higher levels of performance could be that the mothers simply produced more words at 3.5 as a model, and therefore the results of the child language at 4.5 may not have anything to do with fine-tuning. To explore this, regression analysis was performed. It was found that the ratio is indeed a better predictor than the absolute number of instances of the mother's input for lexical skill.

One of the limitations to this study is that the participants may not be perfectly representative of the general population of children with CIs. The children in this sample were only recruited from listening and spoken language educational or therapy settings (LSL), and many of the families in this study were of higher than average socio-economic status and educational level. The results from this study cannot be generalized to children with hearing impairments outside of a LSL setting, children with other hearing devices, or to families in which the mother's educational level is considerably lower than that of the mothers in this study. It is unclear what the relationship may be between mother's educational background and their ability or inclination to fine-tune their utterances to those of their child. Previous studies of children from relatively advantaged samples of children with CIs have found that the earlier the intervention with LSL begins, the more successful the child will be with language outcomes (Moog and Geers, 2010). Another limitation of this study is that it was a correlational study, so there is no proof of causation from the results. We cannot determine the exact cause of child language change based on their mother's input, only that there is a relationship between amount of vocabulary and grammar produced by the mother and child language outcome.

The results from this study are beneficial to parents, educators, and especially early interventionists. Dettman, Ramp, Holt, Dowell, and Courtenay (2011) found that mothers of children with hearing loss do not know how exactly to fine-tune their language for their children. In this study we find fine-tuning to be occurring based on language in the majority of mother-child dyads and this is related to positive outcomes in their children. It is the role of the early interventionist to coach the parent on how to interact with their child. The results of this study can help parents understand that a level of their own language that is just above their child in terms of sentence length and vocabulary complexity is optimal, and a level too far above will not help the child gain language.

Future research might focus on fine-tuning at older ages and higher language levels to determine if the mothers are staying consistent with their fine-tuning and whether this affects language development at higher levels.

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Table 1

Number of children with each processor type

Processor Type	Number of Children
Platinum Speech Processor	2
ESPrit	1
Sprint	33
Tempo +	3
Freedom	6
Harmony	1
Opus 2	1
Platinum Series	8
Platinum Series BTE	1
Platinum	1
S Series	3

Table 2

Mothers' highest education level

Education Level	Number of Mothers
Did Not Finish High School	2
Completed High School	5
Associate's Degree	6
Bachelor's Degree	33
Master's Degree	8
PhD	5
Did Not Respond	1

Table 3

Total family income

Income Level of Family	Number of Mothers
$15000-30000/yr	3
$30000-45000/yr	3
$45000-60000/yr	6
$60000- 75000/yr	8
$75000-90000/yr	3
$90000 or above/yr	21
Did Not Respond	16

Table 4

Correlations between mother-to-child ratios at age 3.5 and child outcome variables at age 4.5 years

	M-C Ratio at 3.5	
Child Outcome at Age 4.5 Years	NDRW	MLU
NDRW	-0.63*	dnc
MLU	dnc	-0.62*
PPVT-III	-0.55*	-0.69*
PLS-3	-0.39*	-0.57*

* $p < .05$

DNC = Did not calculate

Table 5

Correlations among mother-to-child ratios of NDRW and MLU and growth in child variables at age 4.5 years

Mother-Child Ratio	**Child Growth**
NDRW at 3.5	0.09
MLU at 3.5	0.16

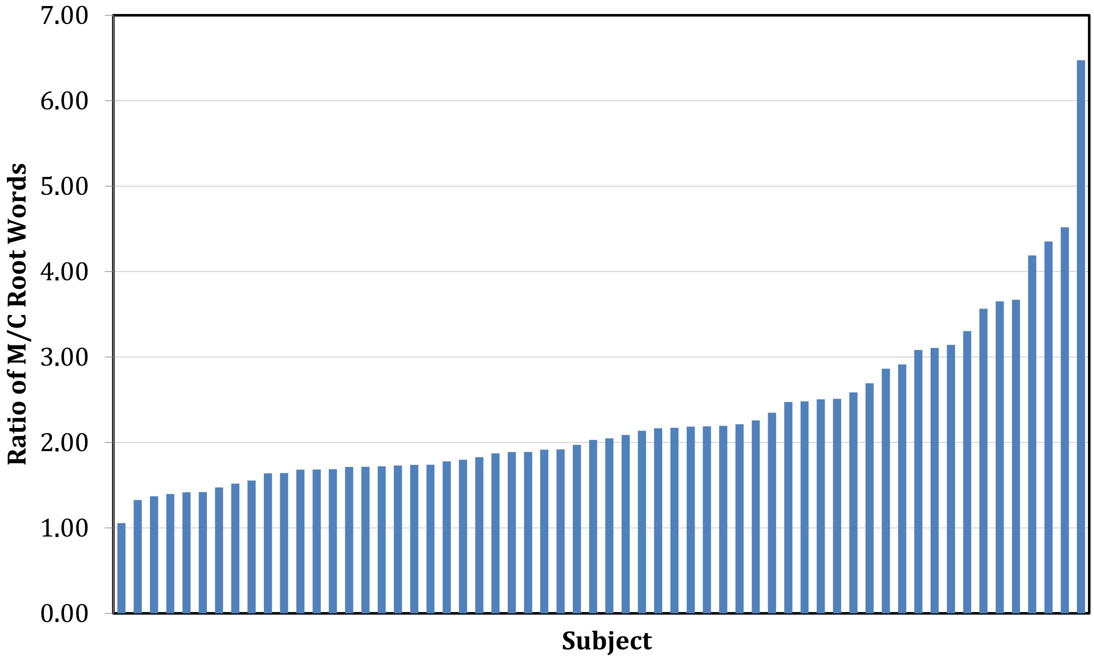

Figure 1. Frequency of the Mother-to-Child Ratios of NDRW at Child's Age 3.5 Years.

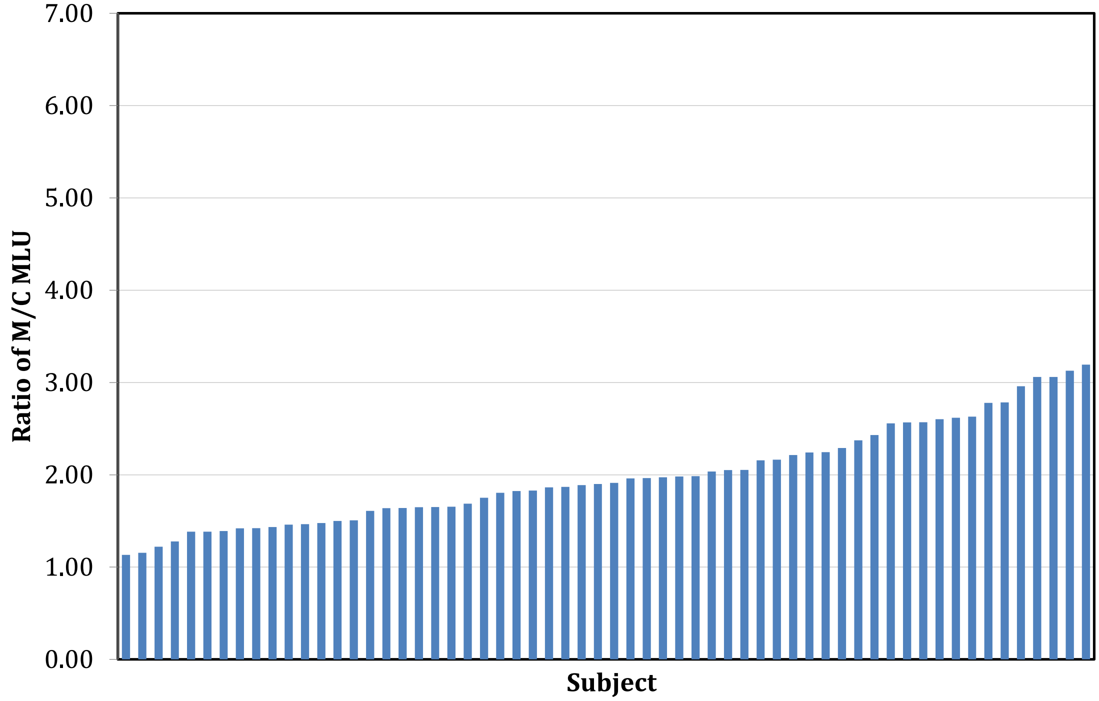

Figure 2. Frequency of the Mother-to-Child Ratios of MLU at Child's Age 3.5 Years.

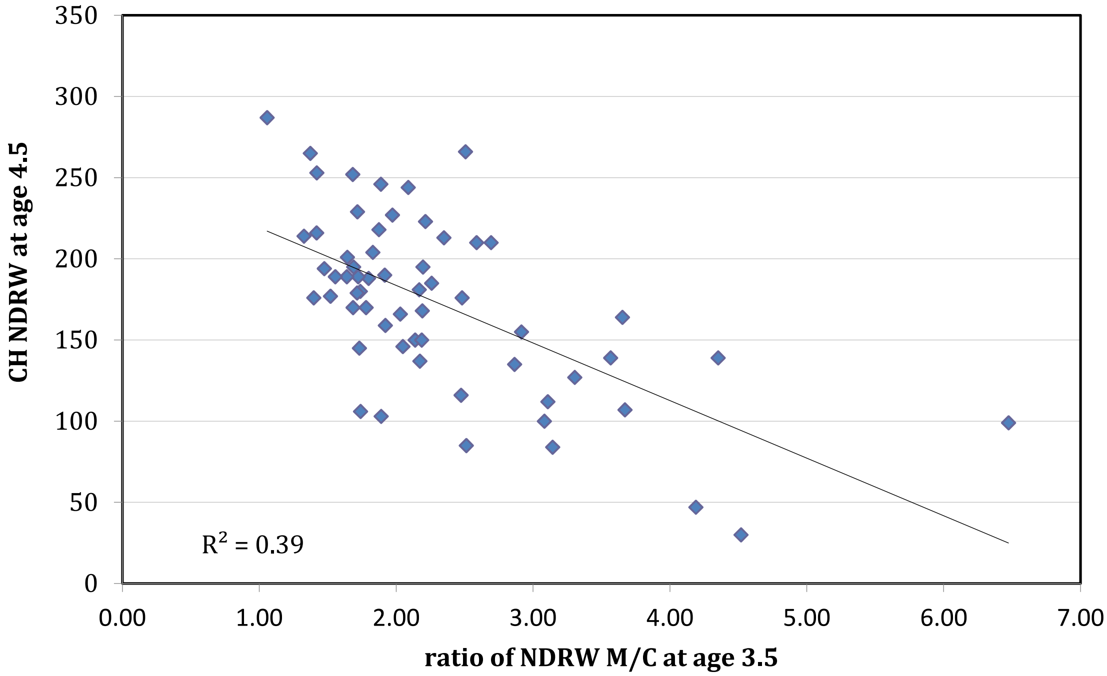

Figure 3. Child NDRW at 4.5 in Relation to Mother-to-Child Ratio of NDRW at 3.5.

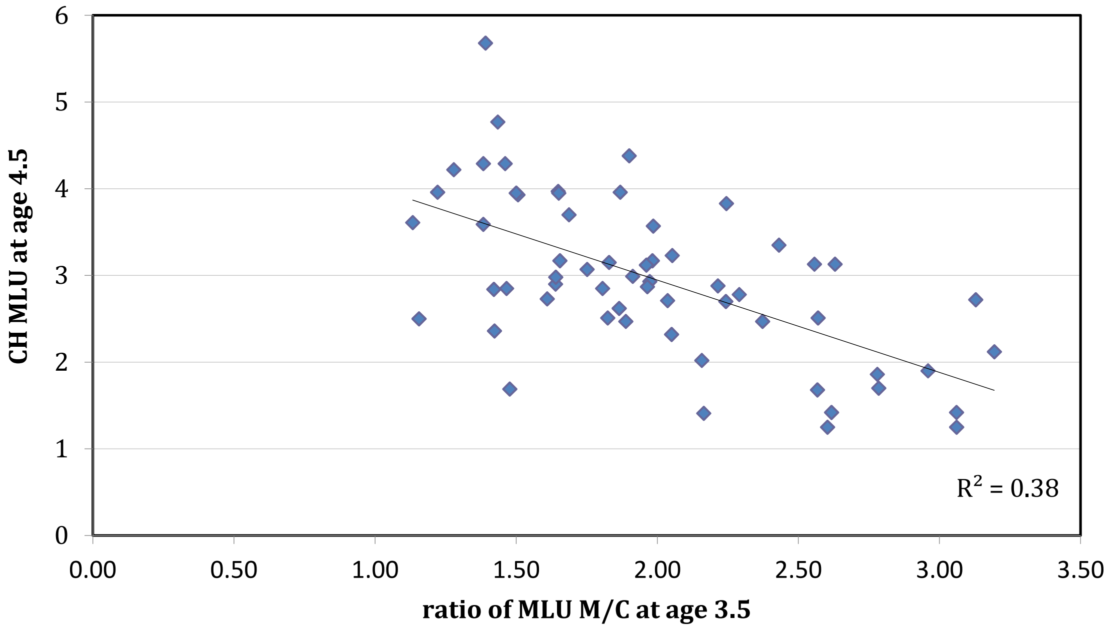

Figure 4. Child MLU at 4.5 in Relation to Mother-to-Child Ratio of MLU at 3.5.

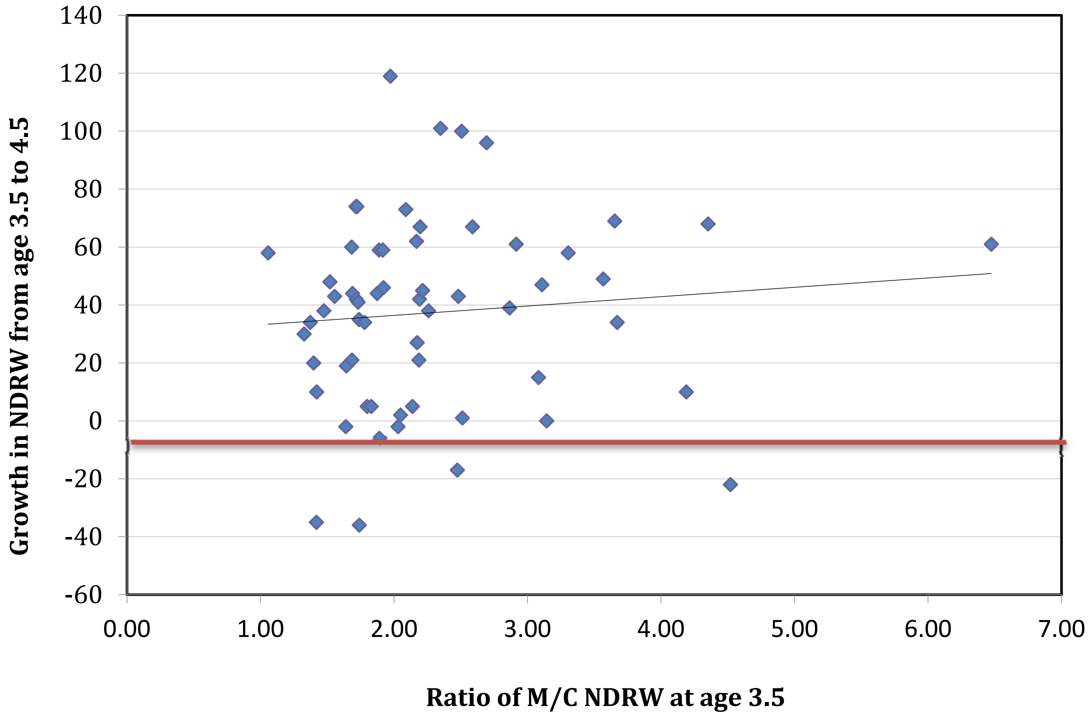

Figure 5. Child Growth in NDRW in Relation to Mother-to-Child Ratio at 3.5.

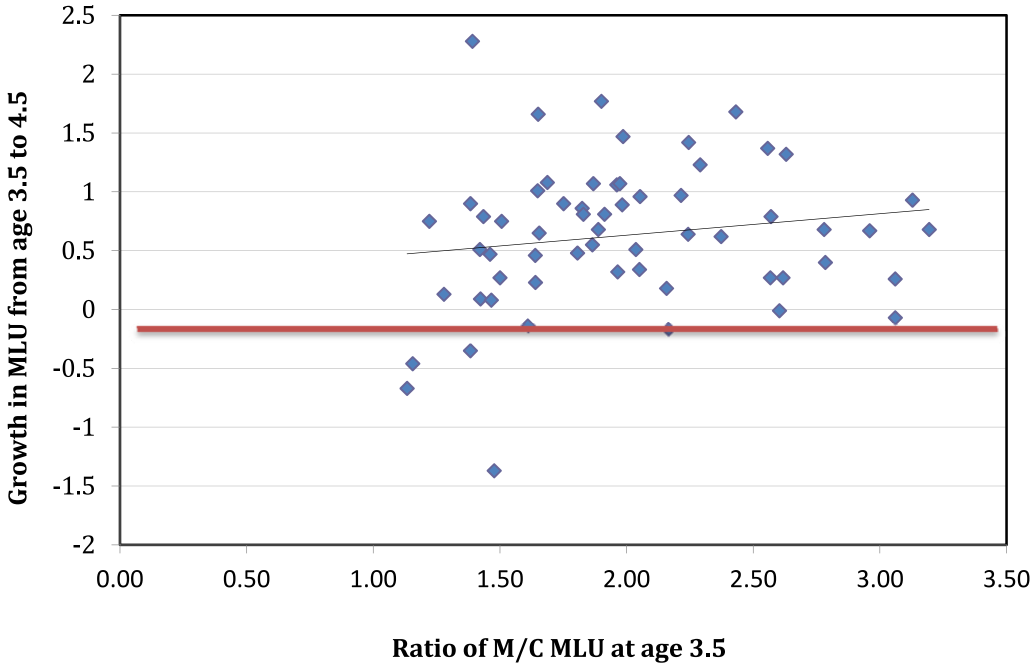

Figure 6. Child Growth in MLU in Relation to Mother-to-Child Ratio at 3.5.

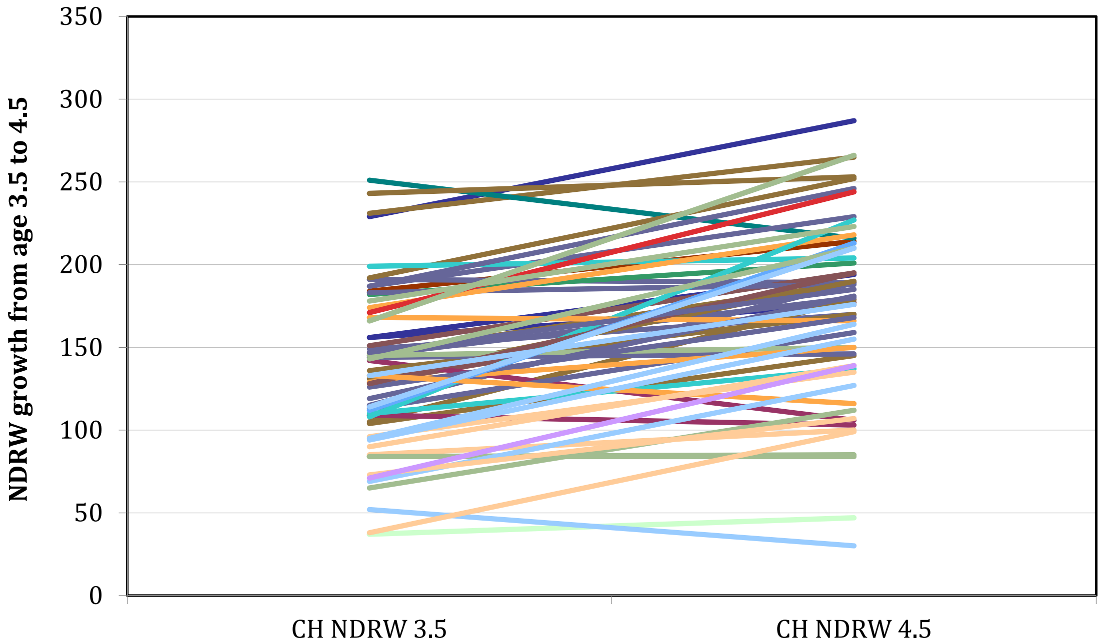

Figure 7. Child Growth in NDRW From Age 3.5 to 4.5 Years of Age.

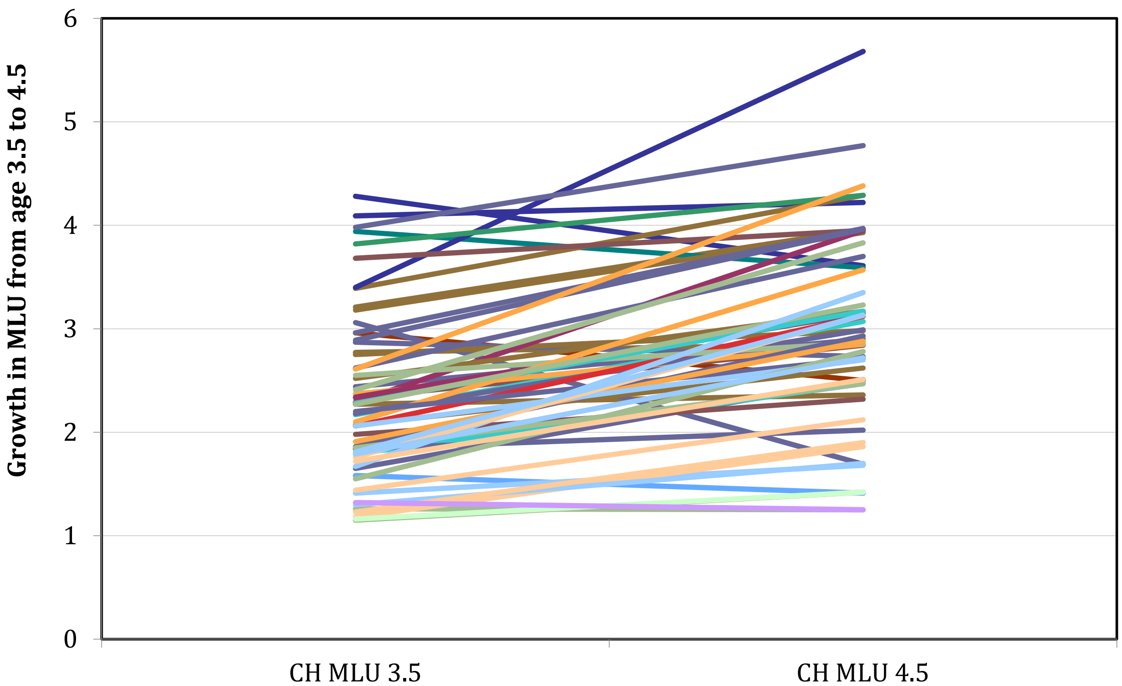

Figure 8. Child Growth in MLU From Age 3.5 to 4.5 Years of Age.