

Language Development for Hearing Impaired Children

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Outline

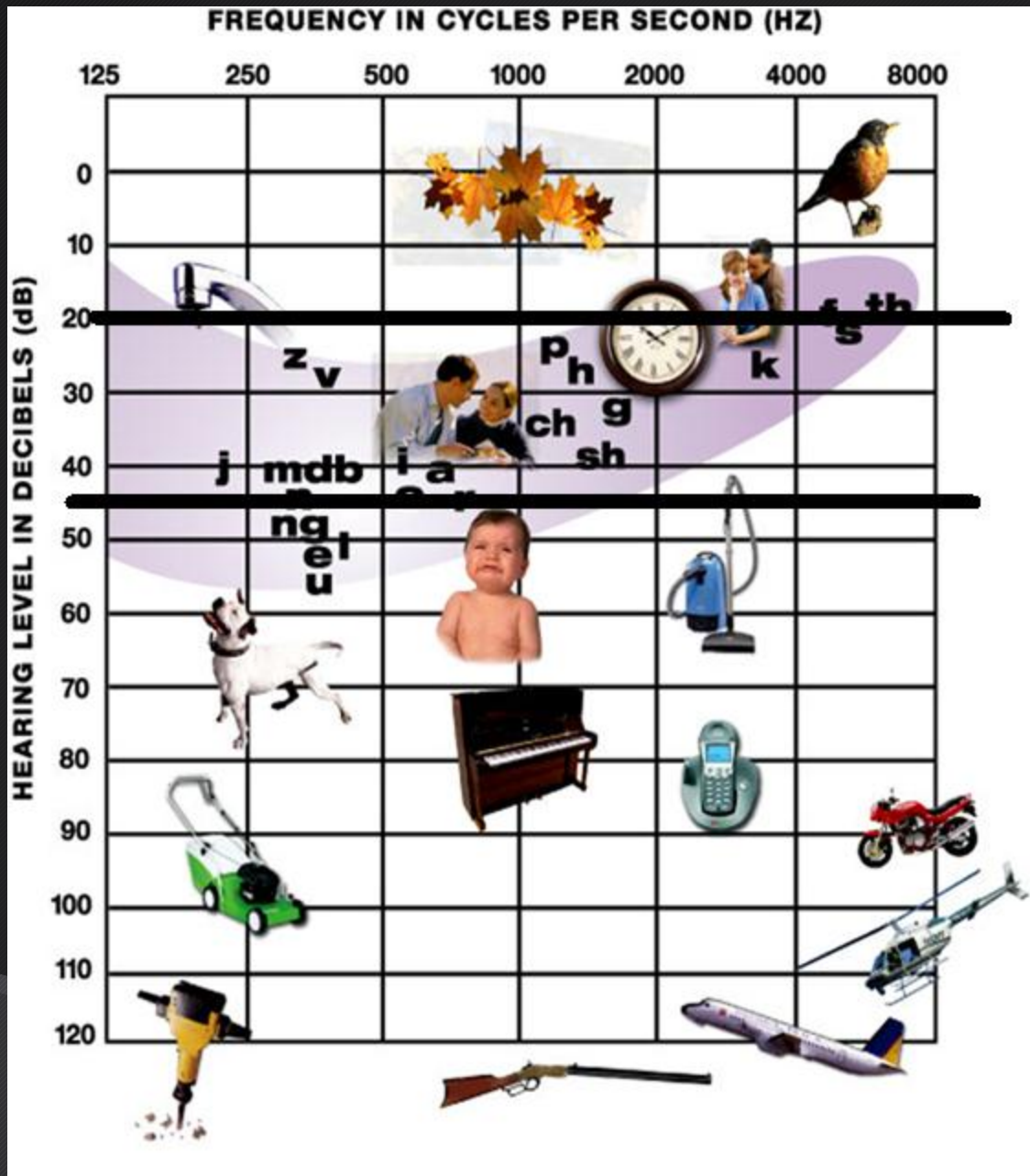
- Introduction
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Introduction

- Hearing loss (HI) is any degree of impairment to comprehend sound
- Known to contribute to psychological and social problems
- Hearing loss has degrees of severity ranging from mild to profound

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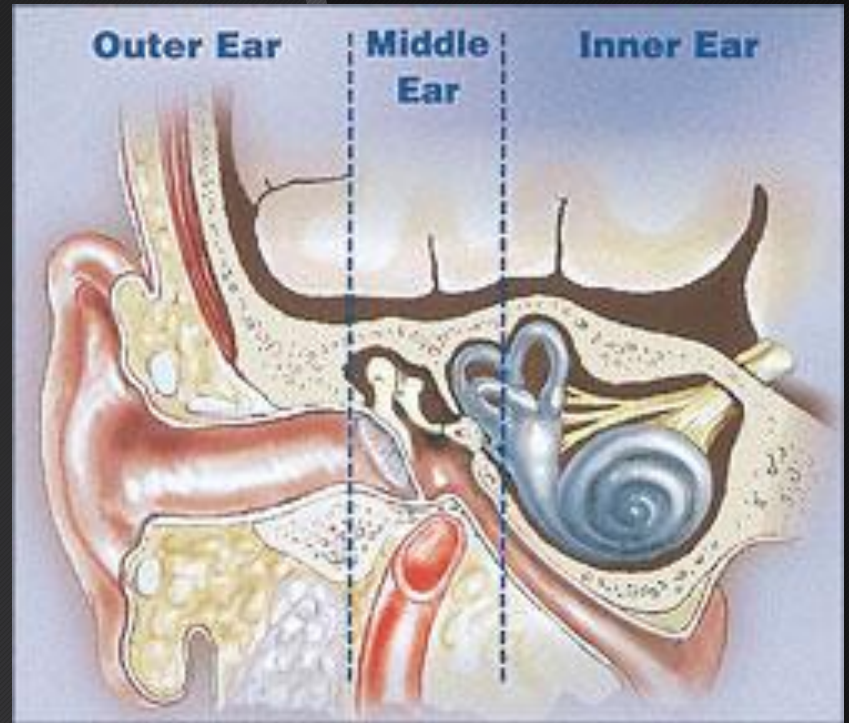
HI



- **Audiogram**-graphically represents type, degree, and pattern of HI
- **Frequency** measures pitch, measured in HZ
 - Low pitches include bass drums, tubas, and vowel sounds
 - High pitches are birds chirping and the sound of "s"
- **Intensity**, measured in dB, tells how loud something.
 - 120 dB is the loudest (i.e. Jackhammer)
 - Soft sounds are the lowest dB (water dripping, leaves rustling)
 - Normal conversation range is whispering at 30 dB to normal conversation loudness at 60 dB

- Estimated population of children with HI is about 900,000 based on data collected by NHANES.
- Early screening in newborns has begun to identify those with HI.
- Once HI has been established, the need for hearing aids or cochlear implants is explored in order to prevent the child from falling behind his peers.

Hearing aids amplify sound through the middle and outer ears by converting the sound waves into electrical signals and sent to amplifier to increase the efficacy of the signals through a speaker





Cochlear Implants directly stimulate the auditory nerve and by passes the damaged cochlea.

They use small electrodes that are surgically implanted into the cochlea and sound is converted into electrical signals.

[Video Link](#)

Background

- Data collected as part of a five year study to achieve numbering of roughly 400 HI and 150 non HI children in Iowa, Nebraska, and North Carolina.
- Seeks to determine the outcomes of children with HI relative to normal hearing peers, especially in linguistic and auditory experiences.
- Looking at data from year one of study
- The study is critical to determine factors that influence speech, social, educational, and psychological views of children with HI.

Objectives

- Preliminary data analysis for study
- Determine if data must be treated as different groups by location or gender
- Find best predictors of Percent Correct Verb, Percent Correct Noun, and MLU
- Test for differences in outcomes between 3 year olds and 6 year olds
- Test for differences between normal hearing and HI children and if factors depend on age

Terms Defined

- **MLU:** Mean Length Utterance, average number of words per statement.
- **Percent Correct Verb:** Verbs Correct/ Total Verb Opportunities. (i.e. He jump_ everyday)
- **Percent Correct Noun:** Nouns Correct/ Total Noun Opportunities. (i.e. Two boy_)

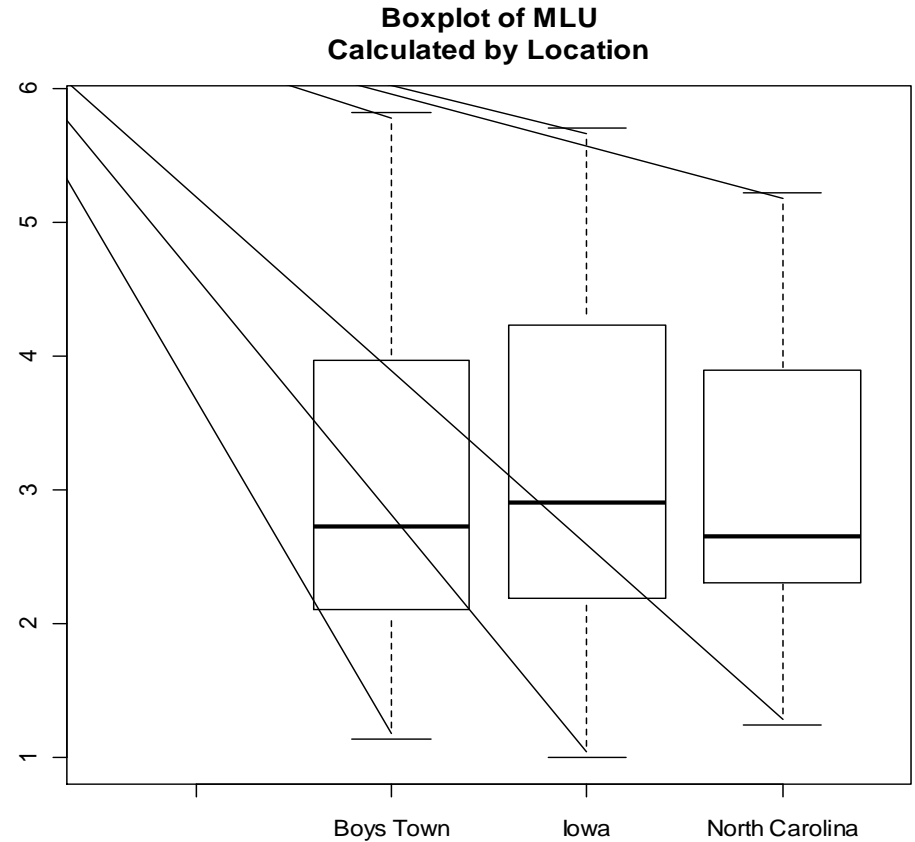
Methods

- T-Tests
- ANOVA(2-way)
- Regression
- Logistic Regression

Results

MLU by location

An ANOVA concluded that the three locations do not have significantly different mean MLUs
 $P=0.5607$



Means:

Boys Town: 3.0506

Iowa: 3.2116

North Carolina: 3.0627

Medians:

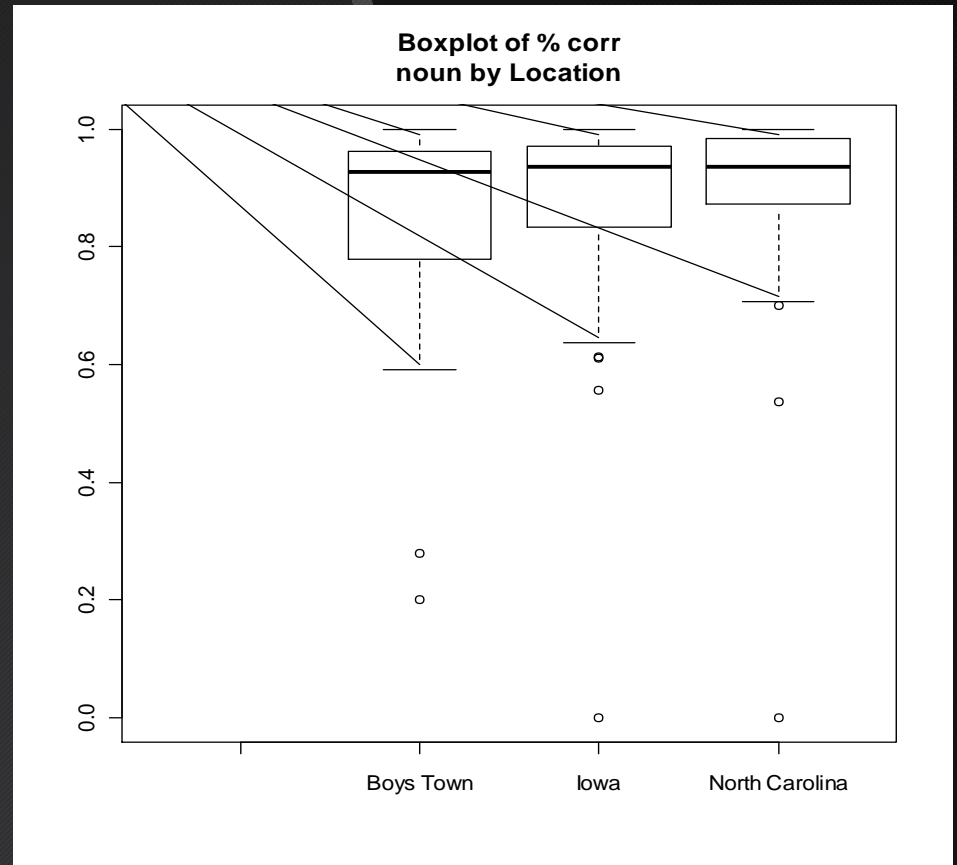
Boys Town: 2.7289

Iowa: 2.9119

North Carolina: 2.66

Percent Correct Noun by Location

An ANOVA concluded that the three locations do not have significantly different mean percent correct nouns
 $P=0.7723$



Means:

Boys Town: 0.8538

Iowa: 0.8714

North Carolina: 0.8803

Medians:

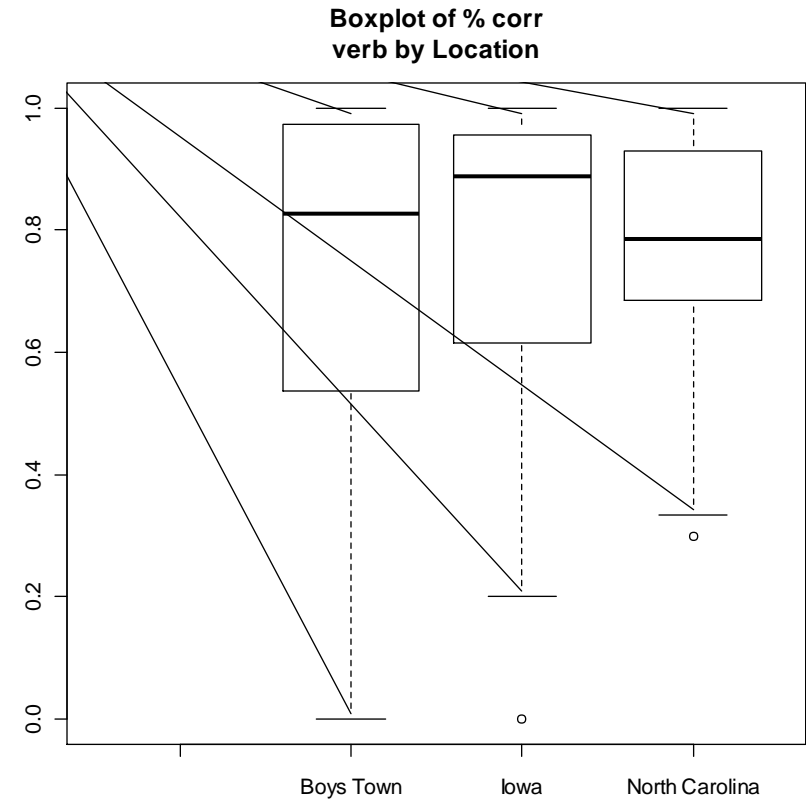
Boys Town: 0.9281

Iowa: 0.9350

North Carolina: 0.9351

Percent Correct Verb by location

An ANOVA concluded
that the three locations
do not have significantly
different mean percent
correct verbs
 $P=0.8372$



Means:

Boys Town: 40.0783

Iowa: 42.0385

North Carolina: 35

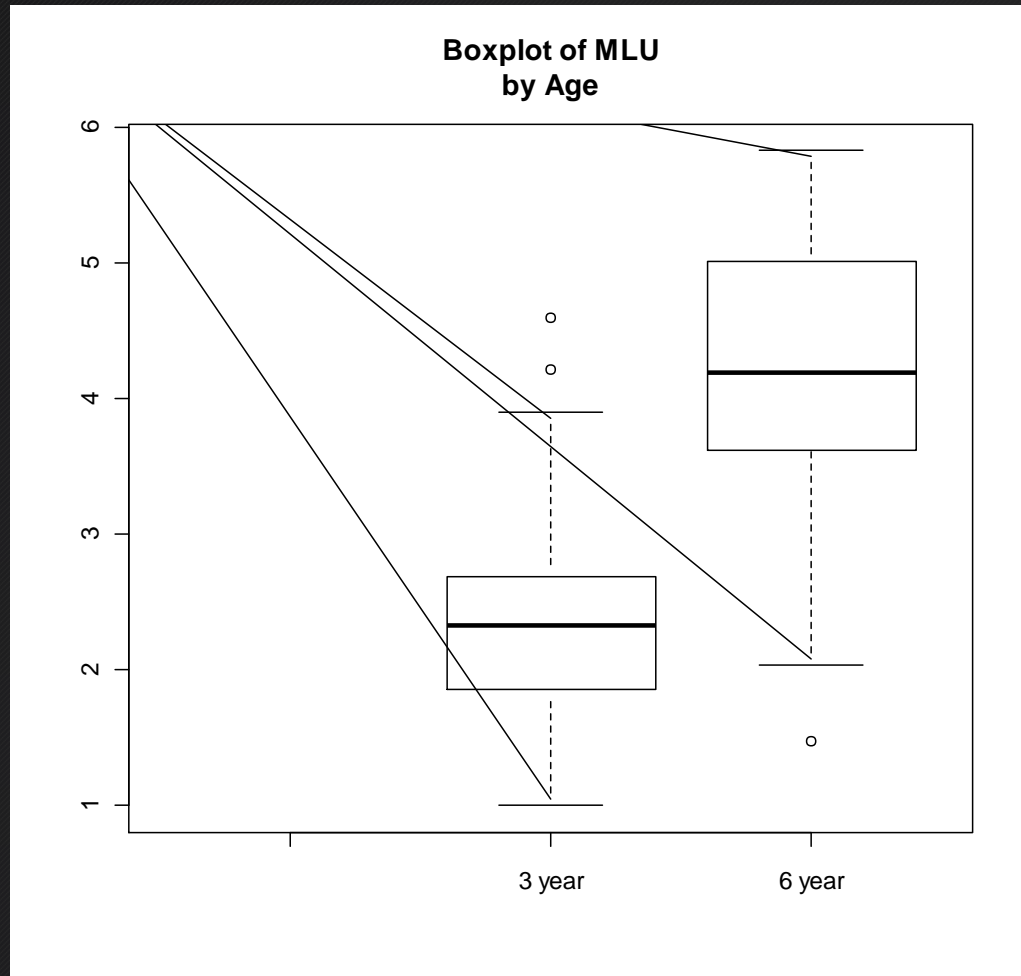
Medians:

Boys Town: 38

Iowa: 31

North Carolina: 35

The variable age



$P=2.0e-16$

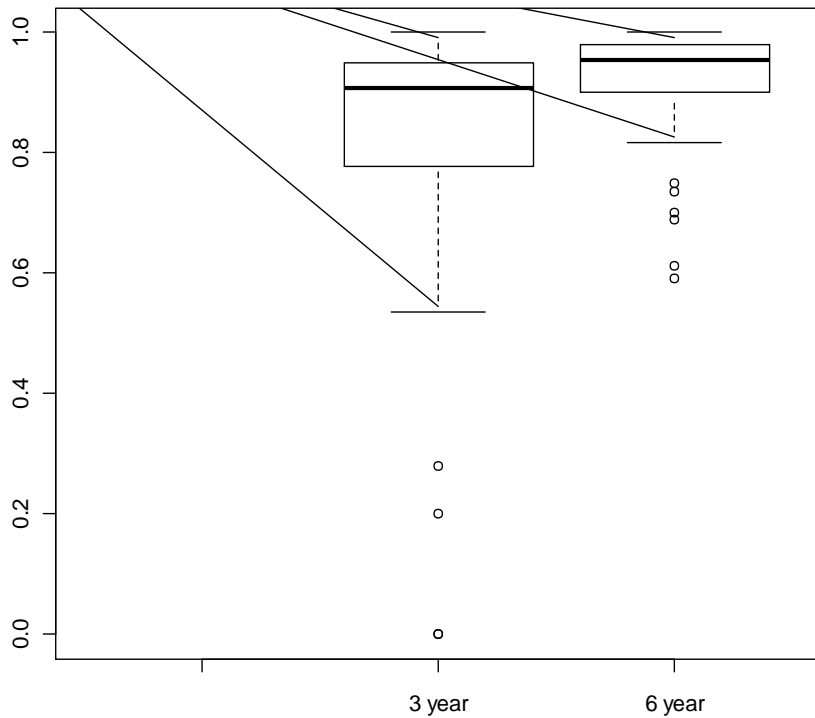
Run in the two way ANOVA with location and for all three variables (MLU, percent correct noun, and percent correct verb), the two age groups had significantly different means

Sample size

3 year olds: n=81

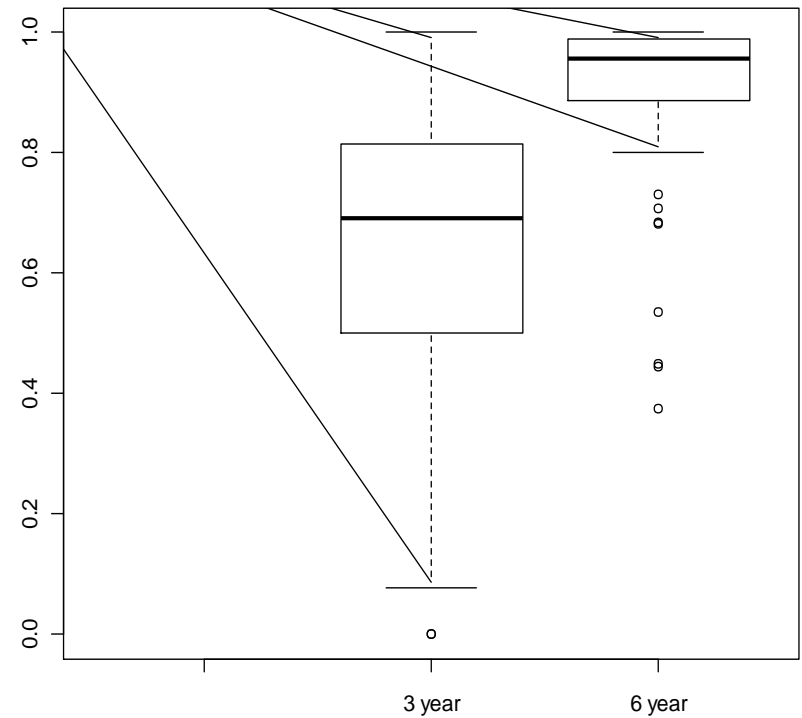
6 year olds: n=58

Boxplot of % corr noun
by Age



$P=0.002223$

Boxplot of % corr verb
by Age



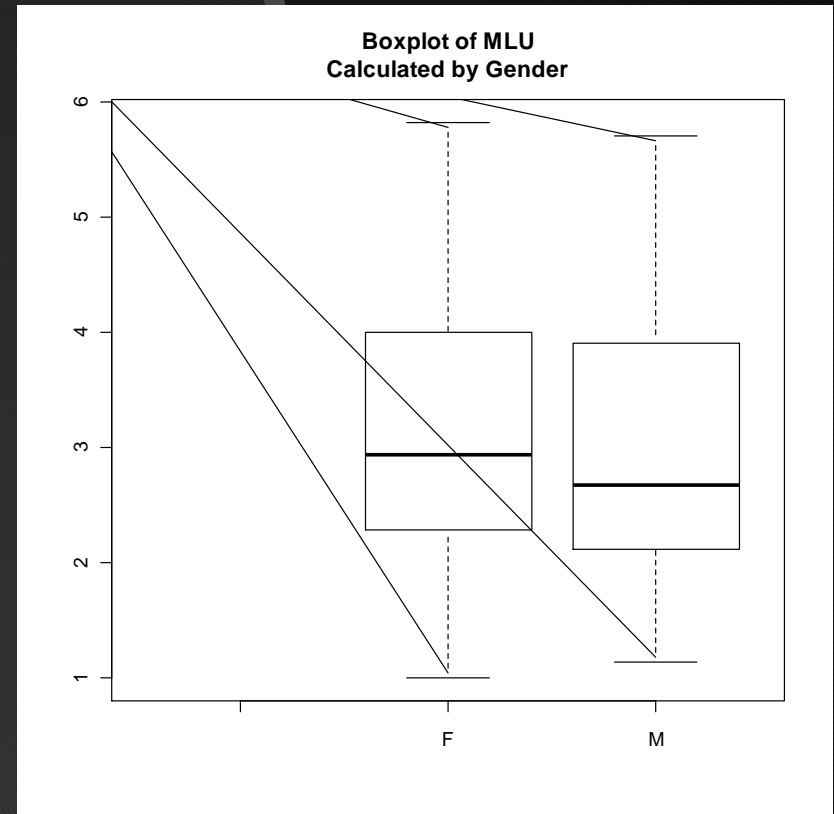
$P=5.437e-10$

Also note: the interaction between age and location was not significant in any of the ANOVAs

MLU by gender

A two sample t-test concluded that the mean MLU for males and females are not significantly different.

($P=.3117$)



Means:

Male: 3.2159

Female: 3.0023

Medians:

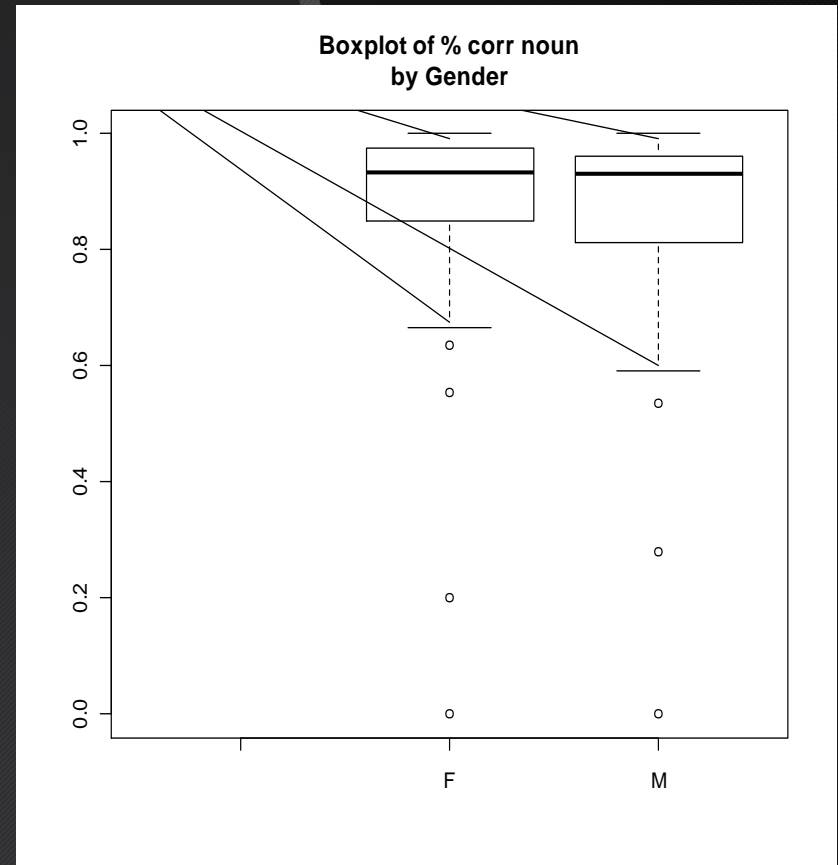
Male: 2.6738

Female: 2.9443

Percent Correct Noun by gender

A two sample t-test concluded that the mean percent correct noun for males and females are not significantly different.

($P=.3274$)



Means:

Male: 0.8517

Female: 0.8818

Medians:

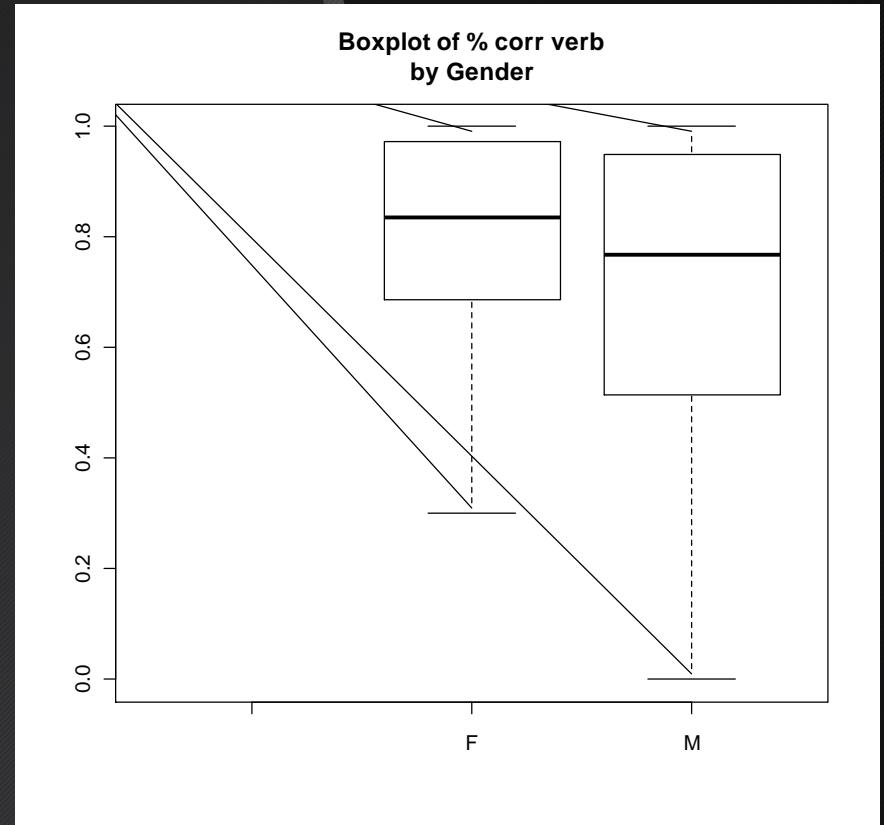
Male: 0.9306

Female: 0.9346

Percent Correct Verb by gender

A two sample t-test concluded that the mean percent correct verb for males and females are not significantly different.

($P=.7782$)



Means:

Male: 38.7647

Female: 40.1250

Medians:

Male: 32.5

Female: 35

- Resulted in no significant differences between gender and location for the three outcome variables.
- Therefore, we combine location and combine gender in all subsequent models.

Predicting MLU a regression model

Variables significant:

percent correct verb (p=.00844)

percent correct noun (p=.02376)

age (p=.00987)

age*percent correct noun
(p=3.28e-05)

Variables included:

- Age
- SII
- PTA
- percent correct noun
- percent correct verb
- age*PTA
- age*SII
- age*percent correct noun
- age*percent correct verb

Final Model:

$$\widehat{MLU} = 0.9606 - 2.2781(\text{age}) + 0.8605(\text{percent correct verb}) + 1.0952(\text{percent correct noun}) + 4.1277(\text{age*percent correct noun})$$

Predicting Percent Correct Noun: a logistic regression model

Variables significant:

MLU (p=0.00207)

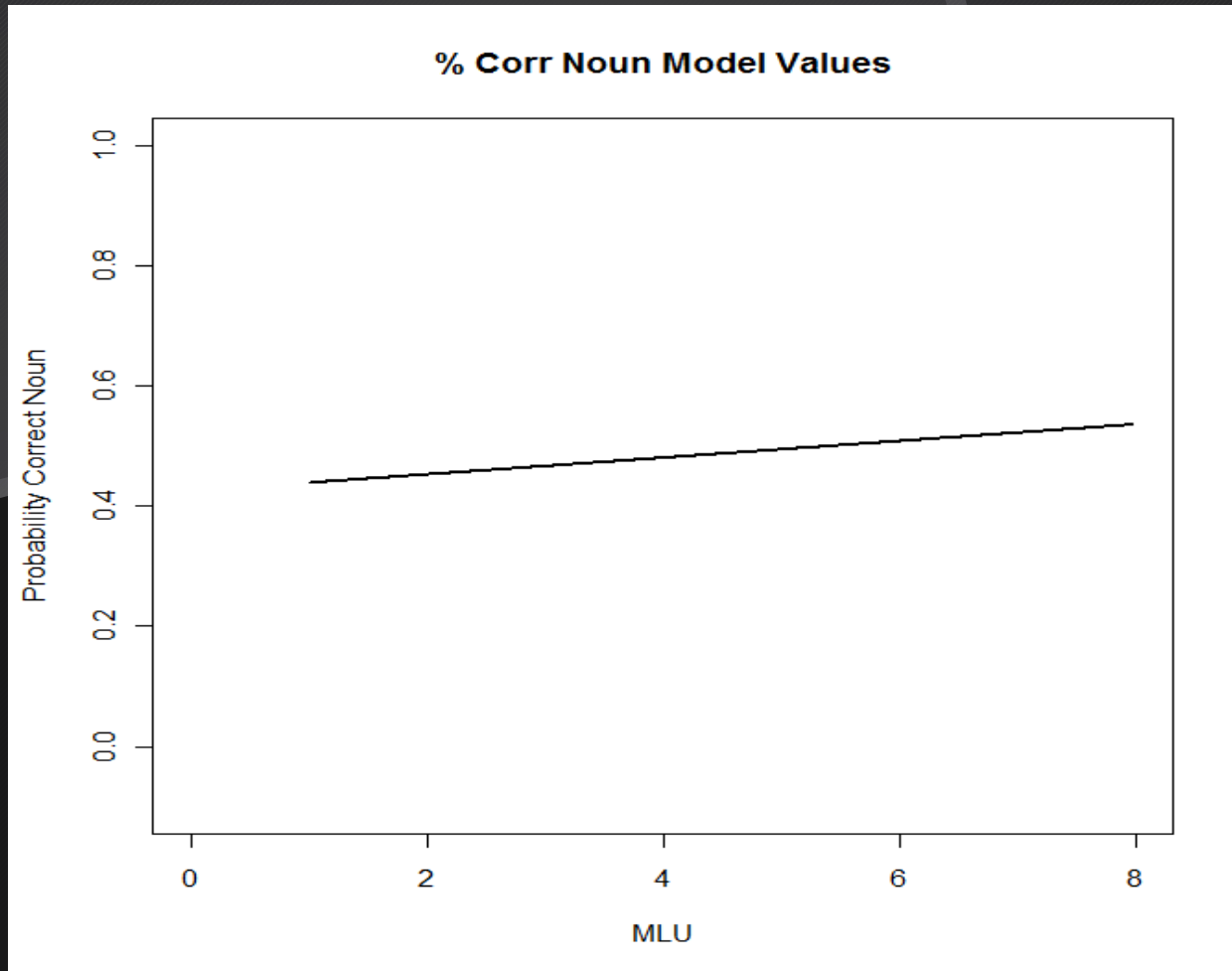
Variables included:

- MLU calculated
- age (3 or 6 years)
- SII
- PTA
- subject type (hearing impaired or normal hearing)
- MLU*age
- SII*age
- PTA*ages
- subject type*age

Final Model:

$$\log \frac{\widehat{\text{percent correct noun}}}{1 - \widehat{\text{percent correct noun}}} = -0.30378 + .05565(\text{MLU})$$

Percent Correct Noun Model



Predicting Percent Correct Verb: a logistic regression model

Variables significant:

MLU (p=2.88e-05),

age (p=.00899)

subject type (p=.01642)

MLU*age (p=.01432)

Variables included:

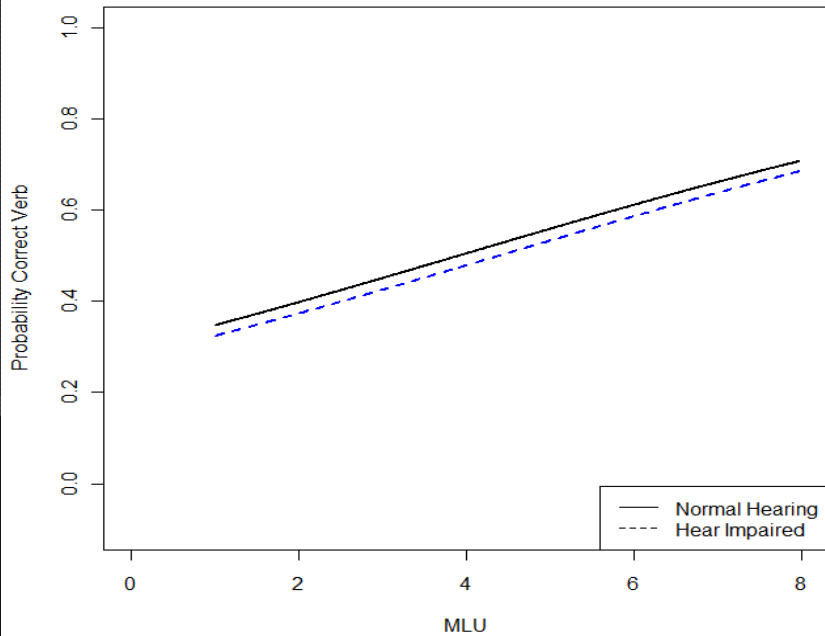
- MLU calculated
- age (3 or 6 years)
- SII
- PTA
- subject type (hearing impaired or normal hearing)
- MLU*age
- SII*age
- PTA*ages
- subject type*age

Final Model:

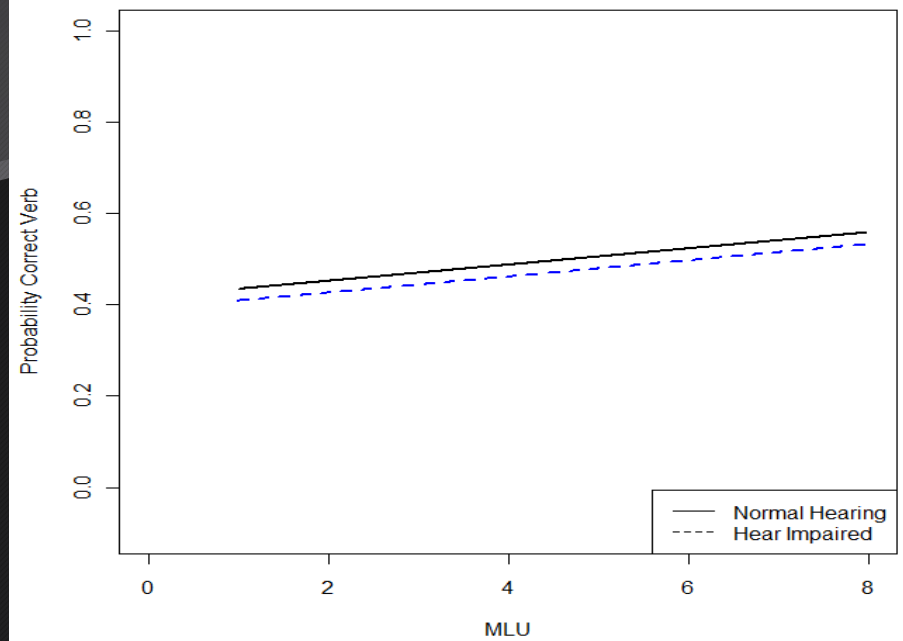
$$\log \frac{\widehat{\text{percent correct verb}}}{1 - \widehat{\text{percent correct verb}}} = -0.95420 + 0.21662(\text{MLU}) + 0.51458(\text{age}) + 0.10428(\text{subject type}) - 0.14555(\text{MLU*age})$$

Logistic Regression Percent Correct Verb

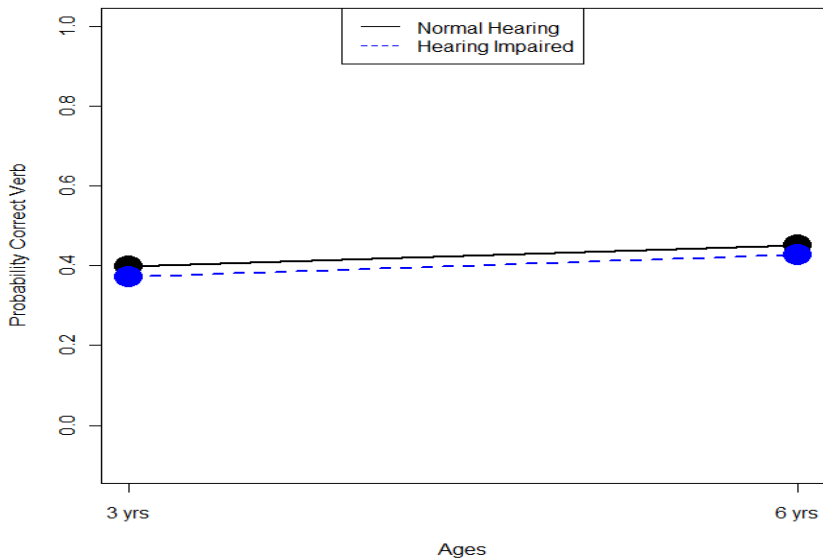
Age 3 % Corr Verb Model Values



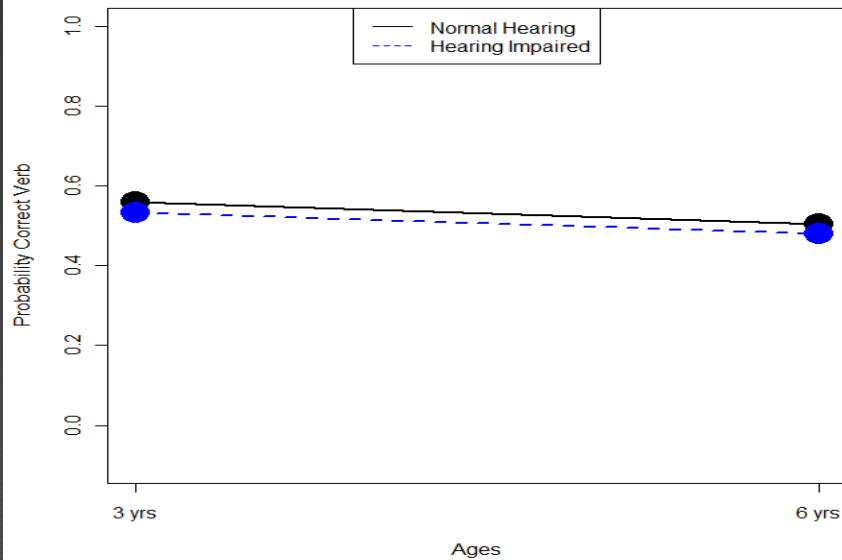
Age 6 % Corr Verb Model Values



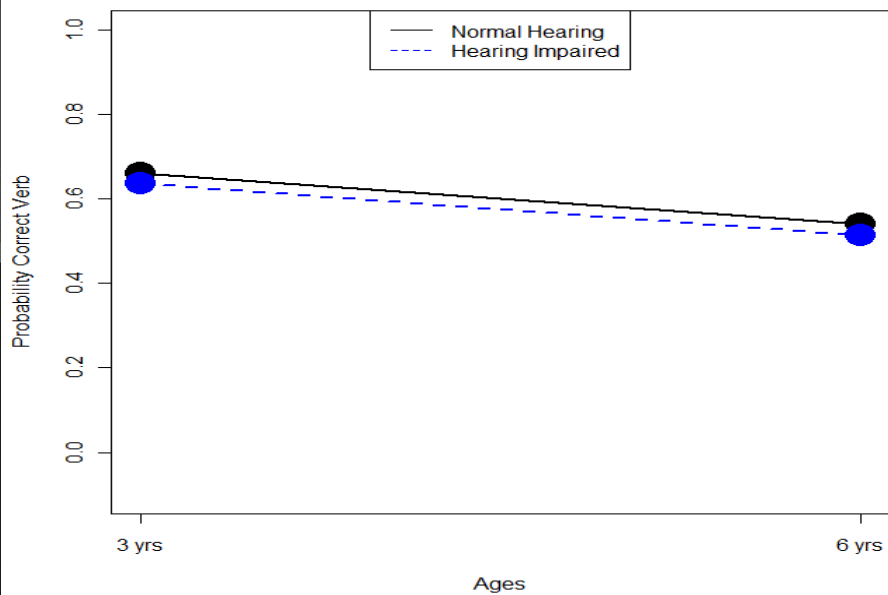
All Ages % Corr Verb MLU Fixed at 2



All Ages % Corr Verb MLU Fixed at 5



All Ages % Corr Verb MLU Fixed at 7



Conclusions

- We determined that the data can be treated as one group with location having little effect on analysis.
- The best predictors of MLU were age, percent correct verb, percent correct noun, and the interaction between age and percent correct noun
- The best predictor of percent correct noun was MLU.
- The best predictors of percent correct verb were MLU, age, subject type, and the interaction between MLU and age.
- Trends showed that 6 year olds had a higher MLU, percent correct verb, and percent correct noun than 3 years, showing not only a difference, but increase.
- We determined a difference between normal children and HI children and that normal hearing children tended to do better.

Future Work

- Relationship between noun and verb
- Socio-Economic Research
- Modification of Learning
- Continue following children to see if trends continue in a longitudinal model

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