

Ability to Recognize Feelings with Musical Stimuli for Individuals with Processing Disorders

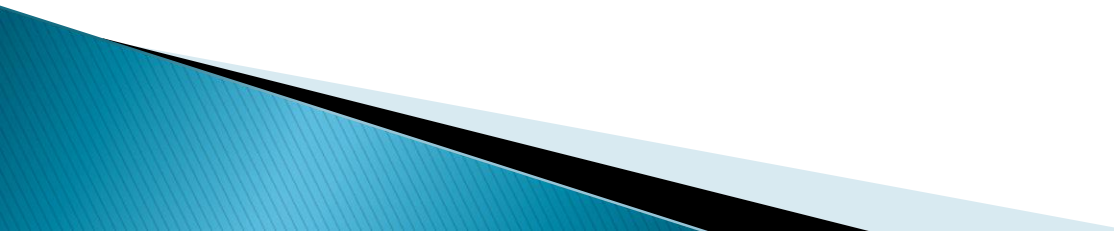
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Introduction

- ▶ Music is pervasive in our everyday environment and knowing how CI users perceive and interpret music is vitally important.
 - ▶ Music is used not only for entertainment but it also conveys emotion such as the music in a scary movie.
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Introduction

▶ Cochlear Implant (CI)

- This is a computerized device assisting people with severe nerve deafness by stimulating the hearing nerve with coded electrical signals
- This is designed primarily to support the perception and interpretation of speech.



Introduction

- ▶ **Autism Spectrum Disorder (ASD)**
 - ASD– is a life–long neurodevelopmental disability with onset before 36 months.
 - One of the areas affected in the children with ASD is the ability to recognize the emotions of others
- ▶ **Typically Developing Children (TD)**
 - Siblings of children with ASD but do not have the disorder themselves.

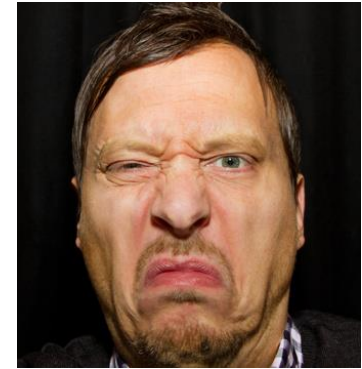
Data Set

- ▶ Department of Otolaryngology
Carver College of Medicine
University of Iowa
 - 166 participants
 - Cochlear Implanted Children (CIC)
 - Cochlear Implanted Adult(CI)
 - Autism Spectrum Disorder(ASD)
 - Typically Developed(TD)
 - Normal Hearing Children(NHC)
 - Normal Hearing Adults(NH)
 - All the participants were tested the ability to recognize different music stimuli
 - Researchers created 3 musical clips (played by the violin) for 5 different emotions and 4 different movements.

Data Set

- ▶ Participants selected from pictures (faces or actions) which emotion or movement they thought they heard.
 - **Emotions**
 - Happy
 - Sad
 - Disgust
 - Fear
 - Anger
 - **Movements**
 - Walk
 - Run
 - Skip
 - Climb

Data Set



Data Set

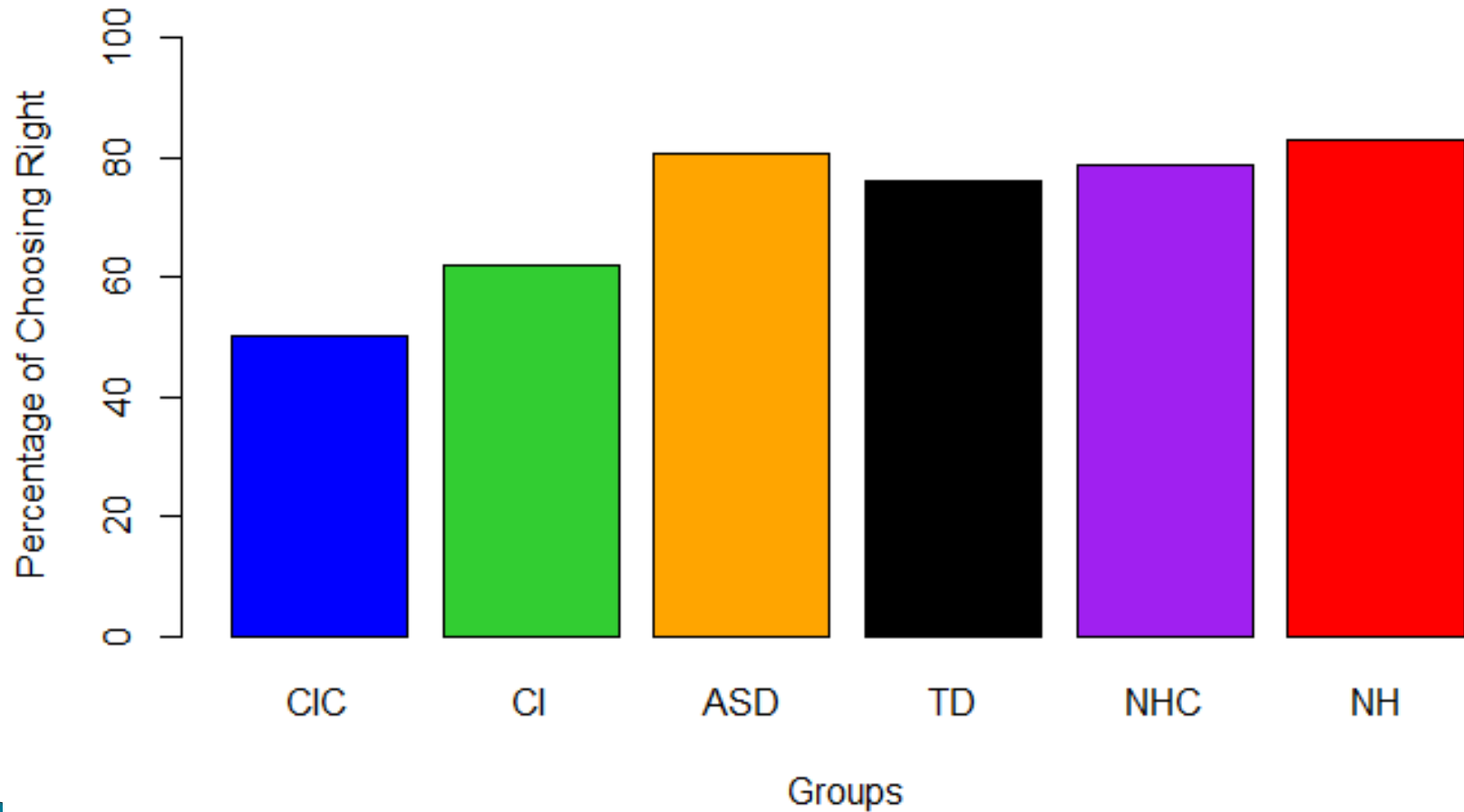


Our Goal

- ▶ Evaluate how children with ASD compare with children wearing CIs in how they perceive and/or recognize emotions and movements presented with musical stimuli.

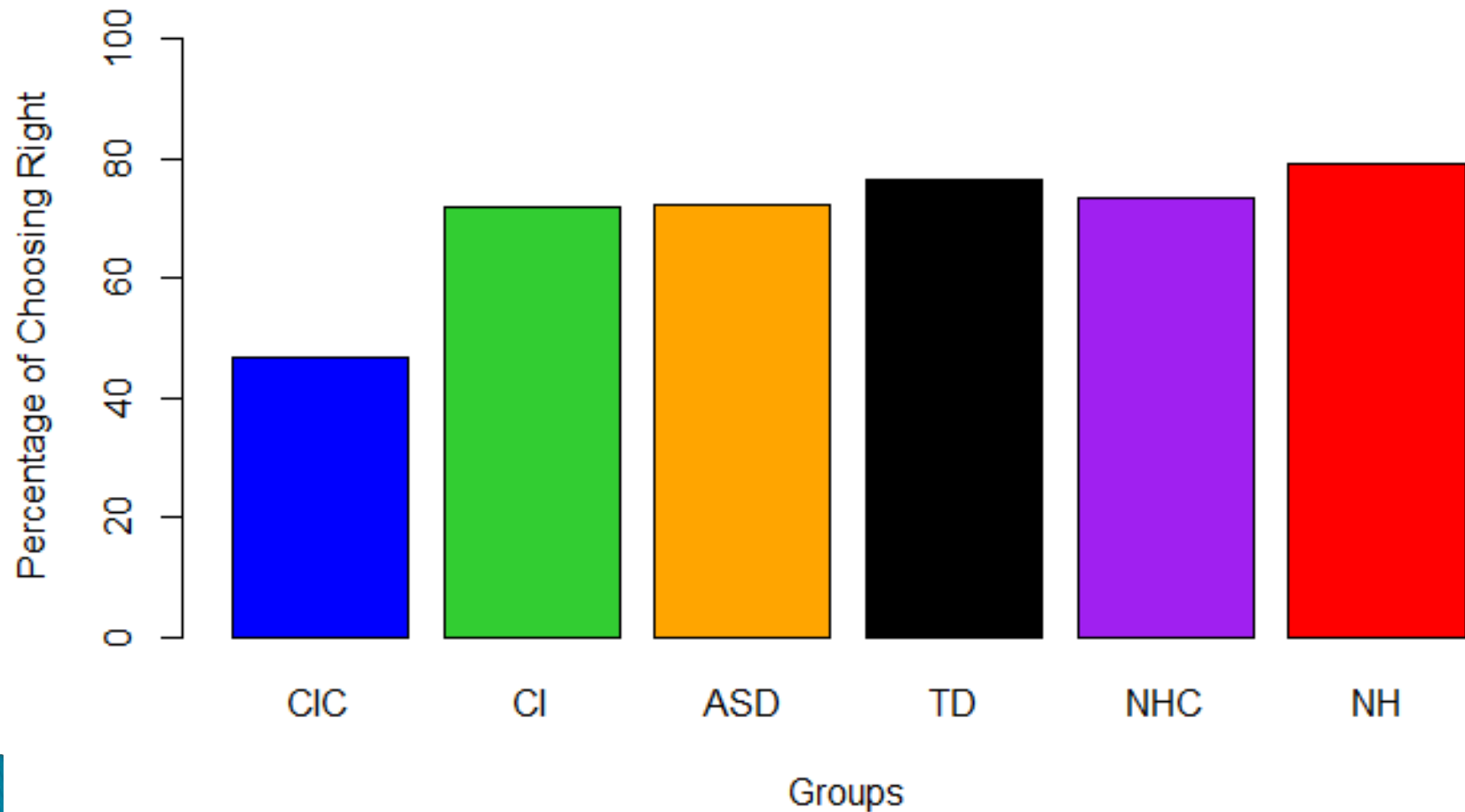
Results

Percentage of Choosing the Right Emotions Among Groups



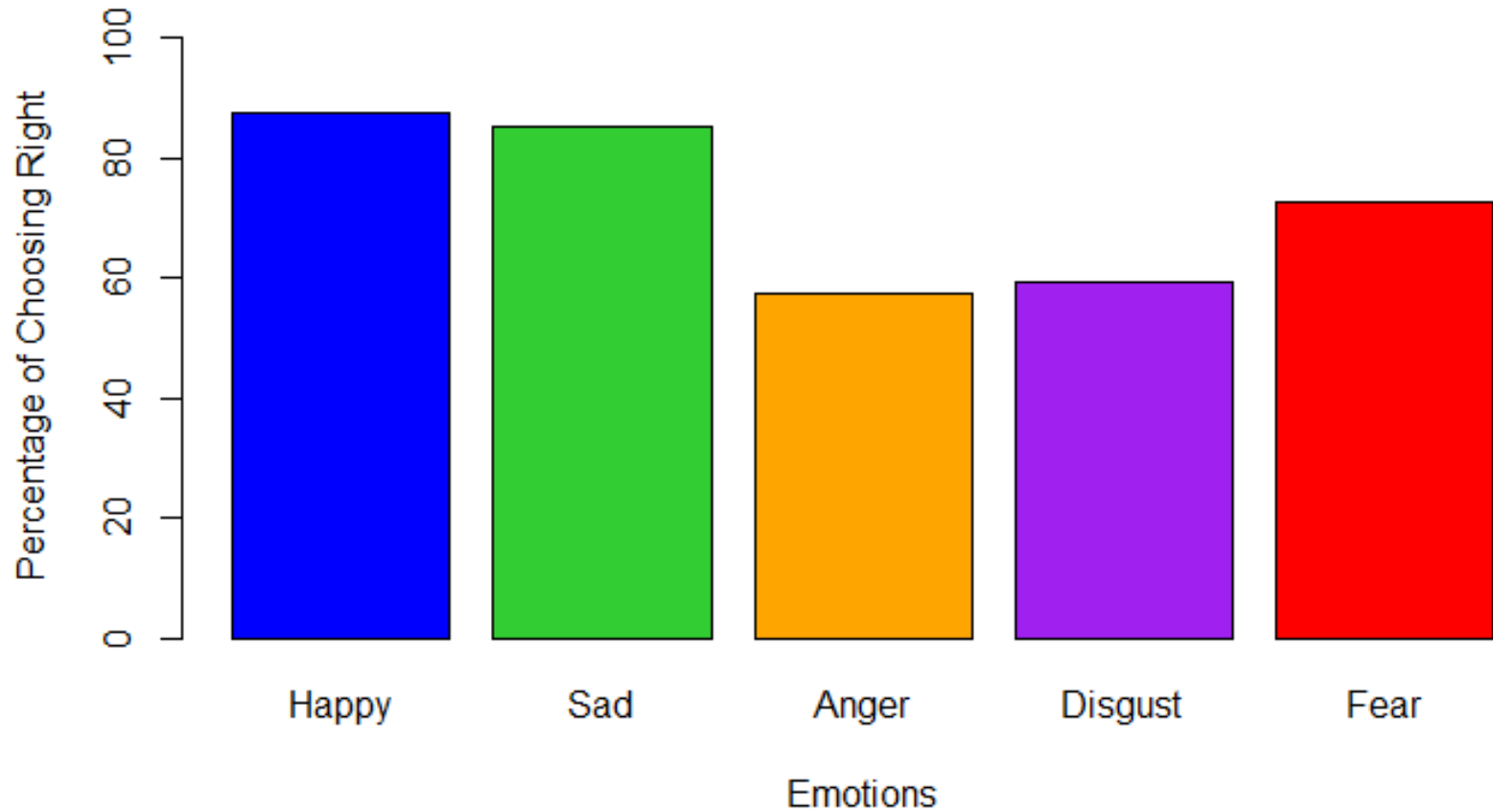
Results

Percentage of Choosing Right Movements Among Groups



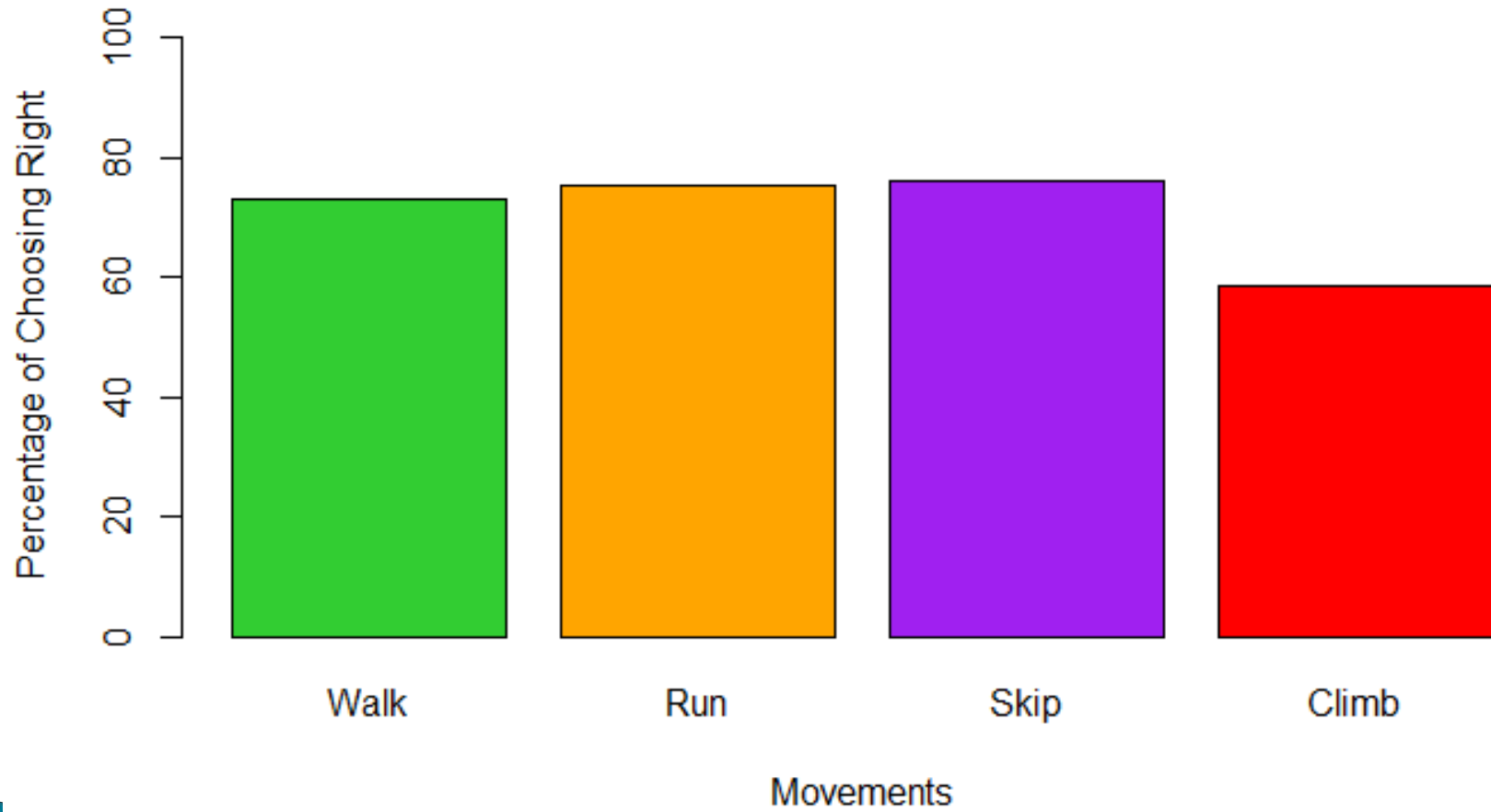
Results

Percentage of Choosing the Right Emotion of All Groups



Results

Percentage of Choosing the Right Movement of All Groups



Methods

- ▶ Hypothesis Testing of Proportions
 - 2 sample Independent Groups
 - $H_0: p_1 = p_2$
 - $H_A: p_1 \neq p_2$
 - $Z = \frac{p_1 - p_2}{\hat{p}(1-\hat{p})\left(\frac{1}{n_1} + \frac{1}{n_2}\right)}$
 - Using Rstudio we used `prop.test`
 - McNemar's Test
 - 2 Dependent Groups
 - $H_0: \pi_{12} = \pi_{21}$
 - $H_A: \pi_{12} \neq \pi_{21}$
 - $\chi^2 = \frac{(n_{12} - n_{21})^2}{n_{12} + n_{21}}$
 - Using Rstudio we used `mcnemar.test`

Methods

- ▶ Repeated Measures for Binomial Data
 - Fit Generalized Estimating Equations (GEE) Models
 - Using Rstudio we used the `geeglm` function.
 - $\log\left(\frac{\pi}{1-\pi}\right) = \beta_0 + \beta_1 Group + \beta_2 Emotion + \beta_3 Group * Emotion$
 - Anova function to perform Wald test for interaction
 - Variance function used is exchangeable
 - $cor(y_{ij}, y_{ik}) = \rho$ for all j, k and $j \neq k$

Data Analysis

▶ Final Model

$$\log\left(\frac{\pi}{1-\pi}\right) = 0.2059 + 0.4301 * Sad - 0.3600 * Disgust - 0.3085 * Fear + 0.0520 * Angry + 1.8418 * CI + 2.6274 * ASD + 3.1953 * TD + 2.5350 * NHC + 2.7119 * NH - 1.2614 * Sad * CI - 1.9366 * Disgust * CI - 2.2247 * Fear * CI - 1.6142 * Anger * CI - 0.4301 * Sad * ASD - 2.0793 * Disgust * ASD - 1.3506 * Fear * ASD - 1.5502 * Anger * ASD - 1.5977 * Sad * TD - 2.6714 * Disgust * TD - 2.8985 * Fear * TD - 2.0935 * Anger * TD - 1.1900 * Sad * NHC - 1.9501 * Disgust * NHC - 1.2929 * Fear * NHC - 1.6534 * Anger * NHC - 0.4301 * Sad * NH - 1.5809 * Disgust * NH - 1.7579 * Fear * NH - 1.3908 * Anger * NH$$

▶ Variables:

- Groups
 - CI- Cochlear Implant Adults
 - ASD- Autism Spectrum Disorder
 - TD- Typically Development
 - NHC- Normal Hearing Children
 - NH-Normal Hearing Adults
- Emotions

Wald test for
interaction:

(p-value = 3.4×10^{-5})

There is interaction

Comparing CIC vs ASD on Sad

- ▶ Log Odds CIC–Sad = $0.2059 + 0.4301$
- ▶ Log Odds ASD–Sad = $0.2059 + 0.4301 + 2.6274 - 0.4301$
- ▶ Odds CIC–Sad = $e^{0.636}$
- ▶ Odds ASD–Sad = $e^{2.8333}$
- ▶ Odds Ratio = Odds ASD–Sad / Odds CIC–Sad
- ▶ Odds Ratio = $e^{2.1973} \approx 9.0$
- ▶ The interpretation is, that the odds of getting sad correct for ASD are 9 times higher than they are for CIC.

Comparing groups

- ▶ Odds Ratio = $\text{NHC-Happy} / \text{CIC-Happy}$
- ▶ Odds Ratio ≈ 12.6

- ▶ Odds Ratio = $\text{TD-Happy} / \text{ASD-Happy}$
- ▶ Odds Ratio ≈ 1.8

- ▶ Odds Ratio = $\text{NH-Anger} / \text{CI-Anger}$
- ▶ Odds Ratio ≈ 3.0

Data Analysis

▶ Final Model

$$\log\left(\frac{\pi}{1-\pi}\right) = 0.1542 + 0.1038 * Run - 0.2568 * Skip - 1.0260 * Climb + 0.4544 * CI + 0.9445 * ASD + 1.4171 * TD + 1.1580 * NHC + 1.3657 * NH + 0.7347 * Run * CI + 1.5200 * Skip * CI + 0.6277 * Climb * CI + 0.2191 * Run * ASD + 0.4110 * Skip * ASD + 0.1505 * Climb * ASD - 0.5619 * Run * TD - 0.2014 * Skip * TD + 0.4014 * Climb * TD + 0.0882 * Run * NHC + 0.9256 * Skip * HNC - 0.4685 * Climb * NHC - 0.3707 * Run * NH + 0.1998 * Skip * NH + 0.6162 * Climb * NH$$

▶ Variables:

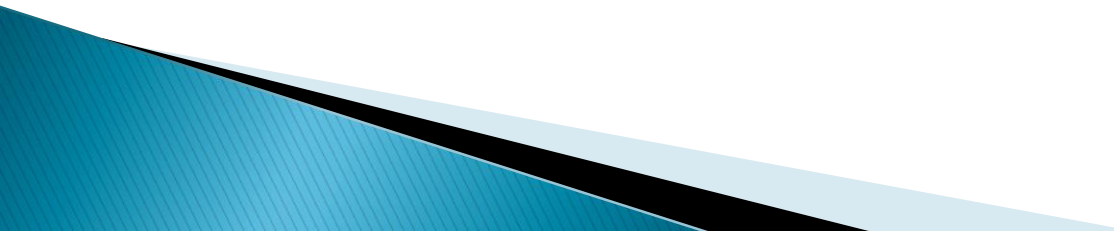
- Groups
 - CI- Cochlear Implant Adults
 - ASD- Autism Spectrum Disorder
 - TD- Typically Development
 - NHC- Normal Hearing Children
 - NH- Normal Hearing Adults
- Movements

Wald Test for
interaction:
(p-value=0.0057)
There is interaction

Comparing groups

- ▶ Odds Ratio = ASD-Walk / CIC-Walk
 - ▶ Odds Ratio ≈ 2.6

 - ▶ Odds Ratio = NHC-Climb / CIC-Climb
 - ▶ Odds Ratio ≈ 2.0

 - ▶ Odds Ratio = ASD-Skip / TD-Skip
 - ▶ Odds Ratio ≈ 1.2
- 

Data Analysis

- ▶ We used the estimated model for all emotions in CIC group

$$\log\left(\frac{\pi}{1-\pi}\right)$$

$$\begin{aligned} &= -1.7048 + 0.0111 * MOU + 0.0117 * AIM + 0.0371 * MMT \\ &+ 2.1591 * Sad + 2.0241 * Disgust + 3.5713 * Fear + 0.5103 \\ &* Anger - 0.0108 * MOU * Sad - 0.0183 * MOU * Disgust \\ &- 0.0263 * MOU * Fear - 0.0034 * MOU * Anger - 0.0177 \\ &* AIM * Sad - 0.0081 * AIM * Disgust - 0.0153 * AIM * Fear \\ &- 0.0008 * AIM * Anger + 0.0298 * MMT * Sad - 0.0114 \\ &* MMT * Disgust - 0.0645 * MMT * Fear - 0.0081 * MMT \\ &* Anger \end{aligned}$$

- ▶ Variables

- *MOU*—Months of Use
- *AIM*—Age implanted in Months
- *MMT*—Months of Music Training
- *Emotions*

Wald Test for
interaction:
(p-value=8.4×10⁻⁵)
There is interaction

Comparing the different predictors

- ▶ Odds Ratio = Odds without MOU-Happy / Odds with MOU-Happy
- ▶ Odds Ratio ≈ 1.01
- ▶ Odds of getting Happy correct are 1.01 times higher for every 1 month increase in cochlear implant use.

- ▶ Odds Ratio = Odds without MMT-Sad / Odds with MMT-Sad
- ▶ Odds Ratio ≈ 1.03

Data Analysis

- ▶ We used the estimated model for all movements in CIC group

$$\log\left(\frac{\pi}{1-\pi}\right)$$

$$\begin{aligned} &= 0.4346 - 0.0083 * MOU + 0.0066 * AIM + 0.0581 * MMT \\ &- 1.0850 * Run - 1.3507 * Skip + 0.0273 * Climb + 0.0136 \\ &* MOU * Run + 0.0036 * MOU * Skip - 0.0143 * MOU \\ &* Climb - 0.0027 * AIM * Run - 0.0011 * AIM * Skip \\ &+ 0.0010 * AIM * Climb - 0.0308 * MMT * Run + 0.1196 \\ &* MMT * Skip + 0.0604 * MMT * Climb \end{aligned}$$

- ▶ Variables
 - *MOU*—Months of Use
 - *AIM*—Age implanted in Months
 - *MMT*—Months of Music Training
 - *Movements*

Wald test for interaction:
(p-value=0.24)
There is no interaction

Data Analysis

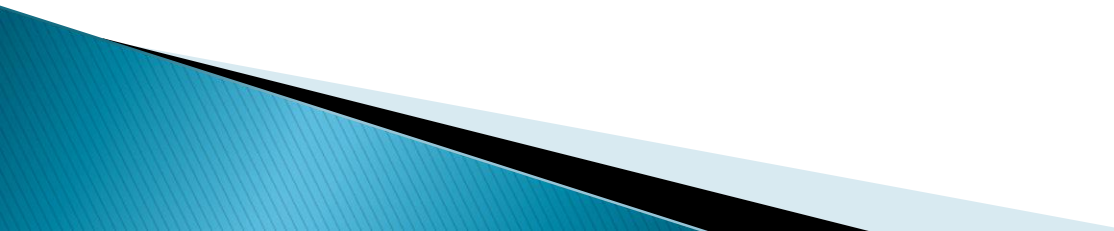
- ▶ We used the estimated model for all movements in CIC group

$$\begin{aligned} \log\left(\frac{\pi}{1-\pi}\right) &= 0.0818 - 0.0068 * MOU + 0.0061 * AIM \\ &+ 0.0924 * MMT + 0.1069 * Run - 0.2652 * Skip \\ &- 1.0602 * Climb \end{aligned}$$

- ▶ Variables
 - *MOU*—Months of Use
 - *AIM*—Age implanted in Months
 - *MMT*—Months of Music Training
 - *Movements*

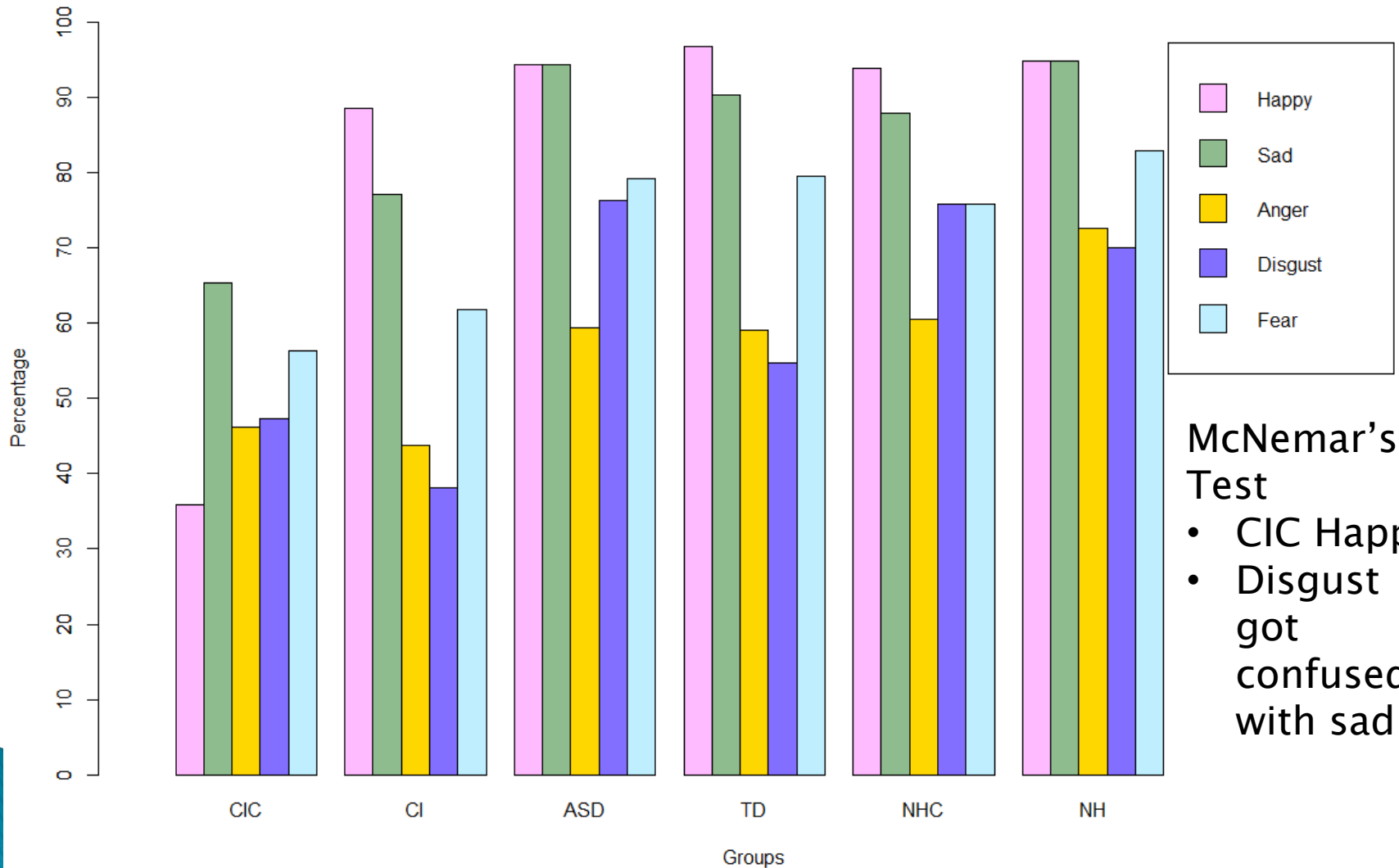
The only significant predictor in this model was Climb

Predictors

- ▶ $AIM \approx 1.01$
 - ▶ The odds of getting a correct answer for Walk in the CIC group increases by 1.01 for every 1 month decrease at which they were implanted.
 - ▶ $MMT(\text{Walk}) \approx 1.10$
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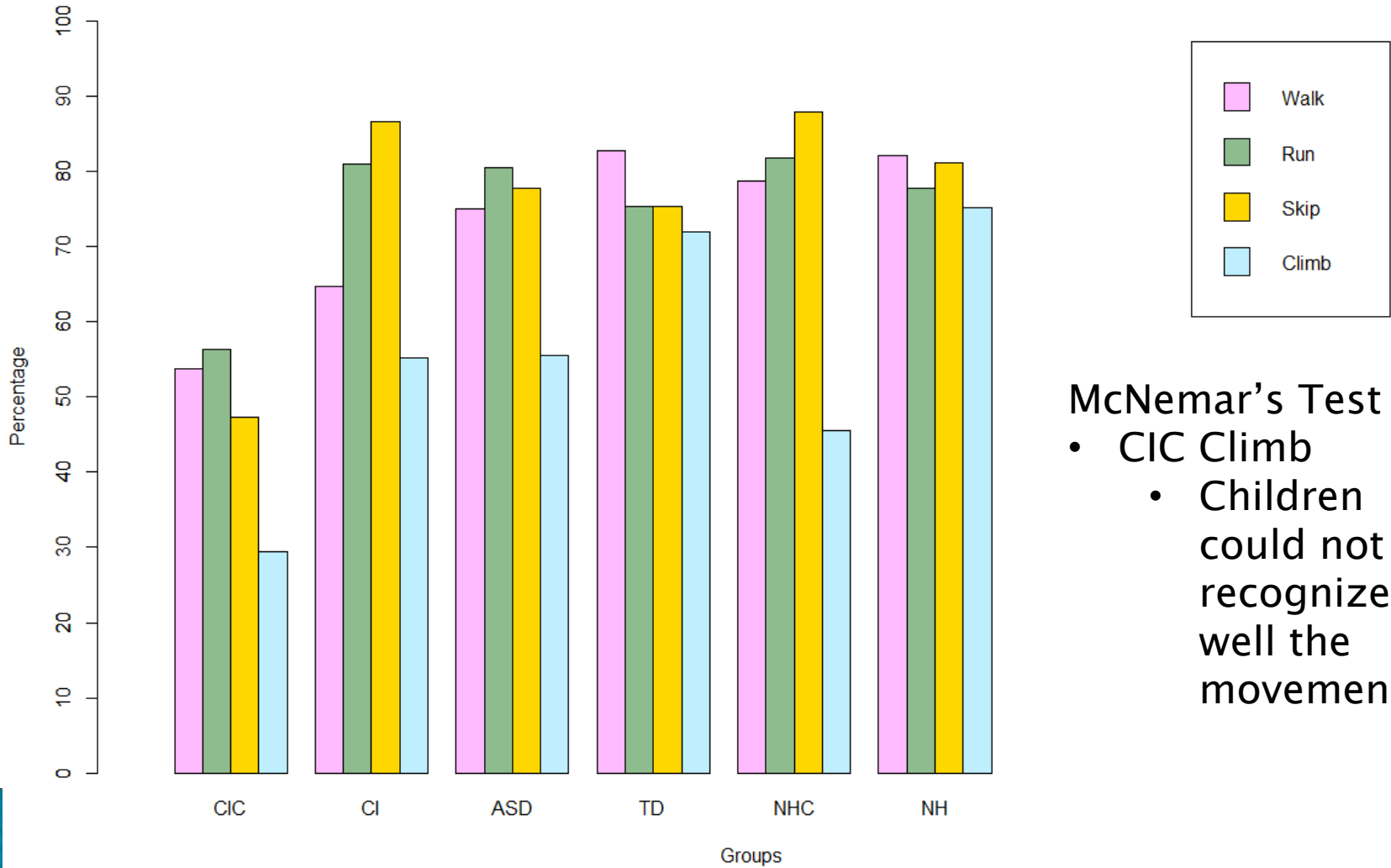
Results

Percentage of Choosing the Right Emotions Between Groups



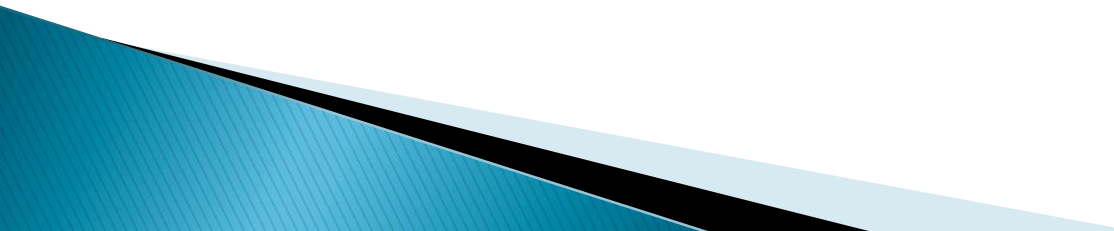
Results

Percentage of Choosing the Right Movements Between Groups



- McNemar's Test
- CIC Climb
 - Children could not recognize well the movement

Conclusions

- ▶ The ASD group did better than expected, while CIC group were expected to be the lowest.
 - ▶ On all but two emotions, CIC had the lowest percent correct.
 - ▶ In all groups there was trouble differentiating sad from disgust.
 - ▶ CIC group could not interpret happy in the music.
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