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The Perception of Emotional Prosody by Listeners with Hearing Loss and Cochlear Implants

Monita Chatterjee, PhD
Auditory Prostheses & Perception Lab
Center for Hearing Research
Boys Town National Research Hospital

Learning Outcomes
After this course, participants will be able to:
- Describe the acoustic cues for vocal emotions.
- Describe how children with CIs communicate vocal emotion in their speech, compared to their normally-hearing peers.
- Describe factors that play a role in the perception of vocal emotion by listeners with cochlear implants and with hearing loss.
Motivation

- Present-day hearing prostheses are focused on speech recognition, not necessarily prosodic cues

- Full communication requires both

- Listeners with CIs have reasonable access to phonetic cues, but are severely limited in access to F0

EMOTION: STIMULI

- 12 sentences, 5 emotion each: happy, angry, sad, neutral, scared (child-directed speech)

- 1 female and 1 male talker (selected from pilot with 4 talkers)

Happy  Angry  Neutral  Sad  Scared
Acoustic Cues for Vocal Emotion

Complex Pitch Cues in NH and CIs

[Graphs showing acoustic cues such as frequency, amplitude, and time dimensions for different emotions and genders]
PRIMARY FOCUS: Cochlear Implants

- Perception of emotional prosody by listeners with CIs
- Production of emotion by listeners with CIs
- Neural plasticity and adaptation in children – age, device experience, linguistic environment
- Cognitive and linguistic development

A Growing Body of Literature Shows Deficits in Both Perception and Production of Emotions by CI Listeners

Deficits in vocal emotion recognition by adults and children with CIs:
- Luo et al., 2007; Hopyan-Misakyan et al., 2009; Schorr et al., 2005; Most & Aviner, 2009; Most & Michaelis, 2012; Chatterjee et al, 2015

Facial emotion recognition/Emotion Understanding in children with CIs:
- Hopyan-Misakyan et al, 2009; Wang et al., 2011; Wiefferink et al 2013; Fengler et al 2017

Imitative production of happy and sad vocal emotions by children with CIs
- Nakata et al., 2012; Wang et al., 2013
Developmental Effect in NH Children Listening to 8-channel NBV Speech

- Age effects in NH children and adults with 8-channel noise-vocoded speech.

Chatterjee et al., 2015 (Hearing Res)
A Closer Look at Individual Data

Chatterjee et al., 2015 (Hearing Res)

Predictors of Performance

1. Sensitivity to static and dynamic changes in F0
2. Age, age at implantation, duration of experience with device
3. Cognitive/linguistic factors
4. SES
Static-F0 Discrimination: Children with CIs have Large Deficits.


Dynamic-F0 CUES: Deficits in CI Children and Adults

Thresholds obtained in all F0 tasks are predictive of performance in emotion recognition tasks.

Even though acoustic cues for emotion are multi-dimensional, F0 remains an important cue for CI listeners.

Newer Data: Benefit of Linguistic Background

(Discrimination)

(Labeling)

Deroche et al. Manuscript in Preparation
Age, Cognitive and Linguistic Factors

- NH children → CI-simulated speech
- CI children → full spectrum speech

NH Children’s Performance with Degraded Speech is Predicted by Age and by Non-verbal IQ

Anna Tinnemore

Tinnemore et al., E & H 2018
What about Children with CIs?

For CDS:
NVIQ was the only variable to have a significant contribution ($\beta = 0.47, p = 0.02$).

For ADS:
-- years of experience using CI had a significant contribution ($\beta = 0.53, p = 0.01$)
-- NVIQ had a marginal contribution ($\beta = 0.37, p = 0.059$).

Vocal Emotion Productions by Children with CIs: Happy and Sad

EXAMPLES...AND INSIGHTS
Vocal Emotion Productions by Children With CIs: Happy and Sad

- 20 sentences:
  - This is it
  - She is here
  - Time to go
  - It's snowing again
  etc.

- Acoustic analyses
- Perceptual data

- 13 children with CIs
- 9 children with NH

Vocal Emotion Productions by Children with CI Show Smaller Acoustic Contrasts than Children with NH

1. Mean F0 ratio [Happy/Sad]
2. Intensity difference in dB [Happy - Sad]

3. The range of F0 (max/min) [Happy/Sad]
Vocal Emotion Productions By Children With CI are also Less Identifiable [Consistent with Smaller Acoustic Contrasts]

But Words in Sentences are Highly Intelligible

<table>
<thead>
<tr>
<th>HAPPY/SAD IDENTIFICATION BY NH LISTENERS</th>
<th>% WORDS CORRECTLY HEARD BY NH LISTENERS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Talkers aged 6-18 years</td>
<td>% Words correctly heard by NH listeners</td>
</tr>
<tr>
<td>Listeners aged 6-18 years</td>
<td></td>
</tr>
</tbody>
</table>

Effects of Aging and Hearing Loss in Adults

Participants
- 32 listeners with bilateral SNHL (ranging from mild to severe) with binaural hearing aids.
- 29 NH listeners.
- Participants ranged in age from 20 – 74 years

Julie Christensen
Post-lingually Deaf Adult CI Users, and Age-related Changes in Vocal Emotion Recognition

SUMMARY

- Acoustic cues for voice emotion include voice pitch, intensity, timbre, duration
- Age and cognitive status predict children’s emotion recognition when cues are degraded (both CI and NH)
- Sensitivity to F0 is predictive of voice emotion recognition in NH and CI groups, adults and children
- Productions of contrastive emotions (happy, sad) by children with CIs show smaller acoustic contrasts and deficits in recognition relative to their NH peers.
- NH listeners show age-related declines in emotion recognition; HL exacerbates the deficit.
- Middle-aged and older NH listeners show deficits in identifying emotions in CI-simulated speech. CI adults seem to show age-related deficits in emotion recognition as well.
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