## A Comparison of Hearing Aid Music-Listening Programs on Perceived Sound Quality of Individual Musical Instruments by Child and Adult Musicians Patti M. Johnstone, Ph.D.(1), Jeff Reinbolt, Ph.D. (2), Jeffrey L. Pappas, D.M.A. (3), Marshall Chasin, Au.D. (4), Jennifer Hausladen, Au.D. (1), Tyler Phillips, M.S. (1), Kristen Thornton, M.A. (1), Karen Martin, M.S. (1) THE UNIVERSITY OF



# RATIONALE

Knowledge is limited about how to design hearing aids to optimize music listening for musicians who may spend hours each day playing an individual musical instrument (2,3,6). To enhance music listening, digital hearing aids may include special signal processing features, for example, a dedicated music program (DMP). It is unknown if DMPs improve the subjective quality of amplified music.

**Research has shown that** music quality can be degraded by wide dynamic range compression (WDRC) (7,8,9,10). WDRC is the most common compression scheme used in digital hearing aids today. The incoming signal is divided into Participants: frequency channels and the input levels for each channel independently measured and adjusted. As a result, WDRC can cause spectral and tempo- Symphony ral smearing that could affect the relationships between har- years) – UT School of Music monics critical in perception of bass fundamental frequency ity at 250-8000 Hz (f0) and the correct identification of some musical instruments.

This study sought to determine the following. Will child and adult musicians, in blind comparisons:

1) Prefer live music recordings of individual musical instruments from hearing aids with an activated DMP as compared to deactivated?

2) Prefer one compression processing scheme over another when listening to live music recordings of individual musical instruments with bass fundamental frequency (f0) and harmonics?

3) Correctly identify an individual musical instrument when listening to live music recordings?

### Stimuli:

 Closed set of 18 live-music recordings for each of 7 musical instruments (bassoon, cello, marimba, trumpet, tuba, xylophone, and violin) (see Figure 1) with a range of harmonic overtones (see Figure 2). Two Music Types: one-octave C major scale (ascending and descending) and a short musical excerpt of their choice.

• Five different hearing aids: Bernafon Juna, Phonak Venture, Starkey Muse, Widex Dream, Oticon Opn; all programmed to a flat 50dB hearing loss using NAL-NL2 targets. DMP activated and deactivated. Audio was recorded through each of the hearing aids into a KEMAR® mannequin Type 45BA transducer and a reference microphone

(Neumann U87).

 Edited into a total of 126 different stimuli.

60 musician participants 30 children (age 8-17 years) – Knoxville Youth



**30 adults (age 18-50 Normal hearing sensitiv-**

Test Setup:

- **Testing done in a quiet room.**
- Participant sat at a table or desk.

• Listened to stimuli via Sennheiser circumaural headphones connected to a laptop computer running a custom MatLab program with a guided user interface.

## **Test Protocol:**

 Demographic survey questions answered first. 7 randomized blocks based on musical instrument. Participants were "blind" to the make of the hearing aid, to DMP activiation/deactivation, and to musical instrument played. Pairwise comparisons made on each listening trial (See Fig. 3). A Quicksort (4,5) algorithm used for

- efficient sorting.

 Resulted in 9 hearing aid outputs rank ordered from the least liked to the most liked for each musical instrument. Participants subjectively rated their top-ranked sample for richness, fidelity, noise distraction, pitch distortion. Willingness to listen to top-ranked sample was indicated in hours.

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Figure 1

# METHODS





Figure 3



## Effect of DMP, Hearing Aid Make and Musical Instrument

A statistically significant main effect was found for DMP activation (F[1,56] = 317.139, p<.0005). In blind comparisons, musicians ranked recordings made with an activated DMP significantly higher than recordings made with a deactivated DMP.

Figure 4: A statistically significant 3-way interaction was found between all three within subjects variables [DMP x Hearing Aid Make x Musical Instrument (F[1,56]= 4.267, p<.05)]. Therefore, the preference for a DMP depended on hearing aid make and musical instrument.

• Figure 5: When the musical instrument had a bass f0 or more bass harmonics (e.g. tuba, bassoon, and marimba), Bernafon Juna with **ChannelFree® compression (DMP on or off) was** ranked significantly higher than all other hearing aids with or without an activated DMP: Phonak Venture (p< .05); Starkey Muse (p< .05); Widex Dream (p<.05); Oticon Opn (p<.05).

 No statistically significant main effect was found for participant Age Group (child versus adult) or for the Music Type played (C major scale versus melody excerpt).

**On average, musicians reported that they** would be willing to listen with their top-choice hearing aid 1-3 hours a day.

The willingness to listen with their top-choice hearing aid correlated significantly and negatively with length of reported musical experience for adults (r = -.503, p< .01) but not children.

In general, for both children and adults, factors that positively correlated with willingness to listen were richness and fidelity. Whereas perceived noise distraction and pitch distortion correlated negatively with willingness to listen for both groups.

 Correct identification of the musical instrument played was significantly lower for children when compared to adults.

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RESULTS

Effect of Participant Age and Music Type Played

Willingness to Listen, Subjective Ratings, Musical Experience, Age

# Bernafon Juna Starkey Muse





# CONCLUSIONS

• Child and adult musicians with normal hearing prefer music recorded through a hearing aid with an activated DMP, however, this preference depends on the hearing aid make and musical instrument listened to at the time.

**Compression schemes like ChannelFree** processing may enhance music perception for musical instruments with bass f0 and harmonics.

Music fidelity, richness, distraction of circuit noise, and pitch distortion are important factors that may influence musicians' willingness to use a hearing aid.

• Length of musical experience (for adult musicians) may negatively affect hearing aid use.

• Length of musical experience may also partially explain the reduced ability of child musicians to correctly identify the musical instrument being played.

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## Acknowledgements

This study was funded through a generous donation to the University of Tennessee from Karen and Rodney Bunn. Thanks to **Christopher Davitt for MatLab support.**