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Effects of Transient Noise Reduction Algorithms on Speech Intelligibility and Perceived Sound Quality

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NORTHERN ILLINOIS UNIVERSITY

Effects of Transient Noise Reduction Algorithms on Speech Intelligibility and Perceived

Sound Quality

A Thesis Submitted to the

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In Partial Fulfillment of the

Requirements of the Baccalaureate Degree

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Department of

Allied Health and Communicative Disorders

By

Anna Benson

DeKalb, Illinois

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**HONORS THESIS ABSTRACT
THESIS SUBMISSION FORM**

AUTHOR: Anna Benson

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Intelligibility and Perceived Sound Quality

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Effects of Transient Noise Reduction Algorithms on Speech Intelligibility and Perceived Sound Quality

I. Background and Significance

Transient noises are noises that last for very short durations. They can be annoying and may also create discomfort and reduce speech understanding for people, especially those with hearing loss. Many hearing aids, therefore, are implemented with transient noise reduction algorithms to reduce the levels of transient noises. As different hearing aid manufacturers implement their transient noise reduction algorithms in different ways, their ability to reduce different transient environmental noises differ. In this study, I, Anna Benson, worked with Dr. King Chung, an Associate Professor in Audiology, to examine the effects of three hearing aid transient noise reduction algorithms on speech intelligibility and sound quality.

Acoustically, transient noises are marked by short durations and sharp rise time (Choi, 2011). Transient noise reduction algorithms implemented in hearing aids are designed to detect these acoustic features to infer the presence of transient noises. Transient noises, if present, are reduced by decreasing the instantaneous gain of the hearing aids (Choi, 2011).

The purpose of this study was to examine the effects of transient noise reduction algorithms on speech intelligibility and sound quality. We wanted to see whether the implementation of these algorithms hindered or aided in speech understanding and sound quality for users.

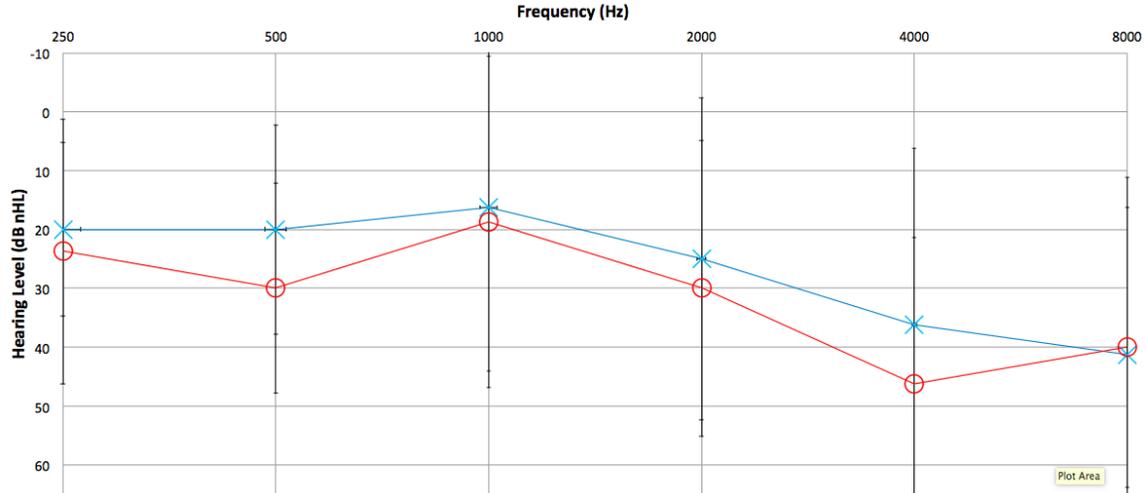
II. Methods

A. Research participants

A Doctor of Audiology student who's Dr. Chung's graduate assistant helped me identify potential subjects with mild to moderate sensorineural hearing loss at the NIU Speech and Hearing Clinic. I sent letters to the potential subjects and invited them to participate in the study. Of this first round of letter sent, I only received one "yes" response to complete the study. A follow up phone call was made after each letter was sent, but there was no response.

A second round of invitations letters was sent out to a group of individuals. We could not access the data of their hearing loss. Due to this, we could not tell if we could use them in our study prior to them arriving to participate in the study. We had 4 individuals participate in our study. The first 3 participants were tested in Dr. Chung's Lab in Wirtz 323.

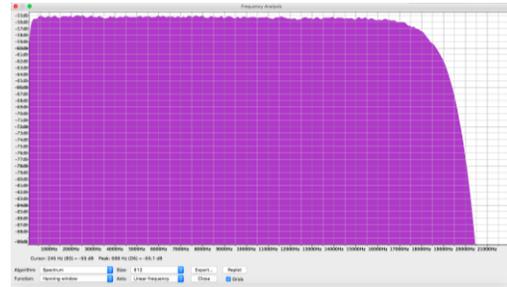
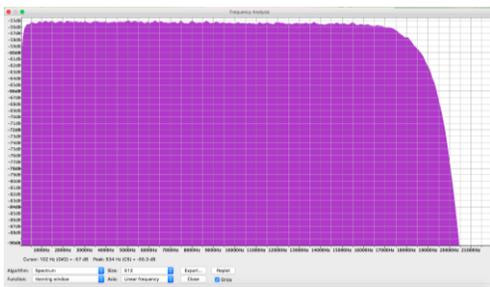
The average hearing thresholds of the participants is depicted below.



One participant preferred to be tested at the NIU Speech-Language-Hearing Clinic. A spectral analysis of pink noise presented to both audiometers (GSI 61) at 70 dB revealed that the audiometers were outputting at the same levels. The program Audacity was used to record audiometer output. Dr. Chung’s Graduate Assistant overlapped the spectrograms to ensure we could test at the clinic as well. The spectrums are shown below:

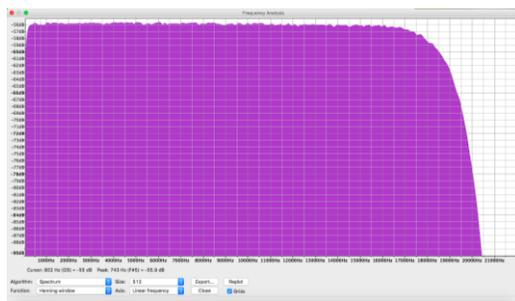
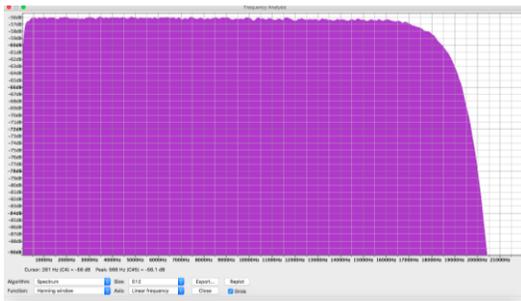
Booth 2 at Clinic – Left 70 dB Pink Noise

Booth 2 at Clinic – Right 70 dB Pink Noise



Wirtz 323 Booth – Left 70 dB Pink Noise

Wirtz 323 Booth – Right 70 dB Pink Noise



The above results indicated that the audiometer in the clinic outputs noise at the same level as the audiometer in Dr. Chung's lab. This is crucial as we analyze our results to maintain consistency and reliability.

B. Recording of the Stimuli

In order to examine the effects of transient noise reduction algorithms, Dr. Chung and her students fitted a Knowles Electronic Manikin for Acoustic Research (KEMAR, Burkhard & Sachs, 1975) with hearing aids, which were programmed for people with mild to moderate hearing loss. They recorded 8 different types of transient noises in the categories of music (cymbal and drum), sports (basketball and clap), construction (hammer and nail gun), and everyday life (door knock and dish cling). They presented the sentences from the Hearing in Noise Test in these noises from the front of the manikin and recorded hearing aid output in KEMAR's ears when the hearing aids were programmed to transient noise reduction algorithms ON or OFF. The acoustic measurements indicated that different transient noise reduction algorithms provided different amounts of reduction for 8 transient noises. Although one of the algorithms consistently provided more noise reduction, it also reduced the hearing aid gain in high frequency regions, which potentially can reduce hearing aid users' speech understanding and perceived sound quality.

C. Loudness Measurement

Upon arrival, the participants' hearing thresholds were tested using standardized audiological procedures prior to participating in the study. To make sure the participants would be listening to the recordings at a comfortable level, we asked the participants to listen to the sentences in the recording and rate how loud they think the speech and noise is. The scale is below:

- 7 = Uncomfortably Loud
- 6 = Loud but Okay
- 5 = Comfortable but Slightly Loud
- 4 = Comfortable
- 3 = Comfortable but Slightly Soft
- 2 = Soft
- 1 = Very Soft

Using ascending and descending 5 dB interval presentations of the sentences, we found each participant's comfortable listening level. We aimed for them to be at a level of an average of 4.

D. Speech Intelligibility Test

Recordings made with the transient noise reduction algorithms ON or OFF were presented to the subjects using the program MatLab. These presentations were given through over the ear headphones. Each subject listened to a total of 8 sentence lists in 2

different types of transient noises processed by 2 hearing aids with transient noise reduction algorithms ON or OFF. The presentation orders of the study conditions were counterbalanced. The subjects repeated the sentences heard and they were encouraged to guess if they were not sure.

E. Sound Quality Ratings

Beside the speech understanding tests, subjects were asked to indicate their preferences of the study conditions using a sound quality-rating paradigm. The recordings of a basketball being dribbled and dishes clanking were presented to the subjects. They listened to a pair of sentences that are processed with transient noise reduction algorithms ON or OFF and then indicated whether they preferred the first or the second sentence, and how much more they preferred the sentence of choice over the other sentence using a 10-point scale with categorical descriptions (Figure 1). Each subject will listen to a total of 48 sound quality rating pairs (i.e., 2 hearing aids x 2 noises x 2 algorithm condition x 4 repetitions).

Figure 1. Sound quality rating instructions and scale.

A. Please tell me which presentation you can understand better:

First Presentation 1	No Preference	Second Presentation 2
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B. Please tell me how much more you can understand the presentation of choice:

Speech Understanding Rating Scale

Slightly More Preferable			Moderately More Preferable				Significantly More		
1	2	3	4	5	6	7	8	9	10

The participants were compensated \$40 at the completion of the study.

IV. Results

A 3 way ANOVA was conducted. The results showed no significant main factors for hearing aid noise type and algorithm ON and OFF. This was shown by none of the p values being smaller than 0.05.

V. Conclusion

Due to the small number of subjects, the results are not conclusive. But the preliminary results show there is not a difference between ON and OFF of hearing aids. This study can be used as a foundational study for future studies on transient noise reduction algorithms specific to individuals with hearing loss.

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