Development of the Sound Acceptability Test (SAT)

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Introduction

Acceptability of everyday non-speech sounds has been found to relate to hearing aid use and satisfaction. Hernandez et al (2006) suggested that hearing aid wearers' annoyance ratings of everyday noises are determined by a combination of duration and intensity. As a result of these and other researchers' findings, advanced hearing aid features have been developed to improve acceptability of non-speech sounds of varying intensity and duration. It is challenging to demonstrate the effectiveness of many advanced hearing aid technologies because no standardized, validated method exists for assessing hearing aid users' acceptance of amplified non-speech sounds in a real-world environment. Recorded sounds with limited non-auditory cues have been found to be inaccurate predictors of loudness discomfort in real life (e.g., Keidser, Bentler, and Kiessling, 2010). This research was designed to develop such a method.

The Sound Acceptability Test (SAT) was designed to quantify the effectiveness of those hearing aid features that, when used alone or in combination, are intended to improve the acceptability of real-world non-speech sounds.

In the development of this method, the following questions were explored:

- What stimuli are desirable for measuring acceptability?
- What is the effect of sound duration on ratings of acceptability?
- What is the effect of sound intensity on ratings of acceptability?

SAT Stimuli: What we were looking for

Variety:

❖ It was desirable that sounds of a variety of intensities, durations, and frequency responses be represented for this test. Ideas for small, common, real-world noisemakers were generated through review of literature, and collaborative brainstorming.

Reproducibility:

❖ It was necessary that each noisemaker was capable of producing sounds that were consistent across presentations and presenters. Methods for producing each sound were standardized.

❖ To document duration, overall level and frequency response for each presentation, sounds were presented in a sound-treated room using the standardized methods.

Limited within-subject variability:

❖ It was desirable that acceptability ratings for a single stimulus be relatively repeatable from one trial to another for a single participant. This ensured that the test was sensitive to differences in hearing aids if differences existed.

Sufficient between-subject variability:

❖ It was desirable that each test stimulus have a range of acceptability ratings across subjects to tease apart differences among hearing aid users, and/or hearing aid technologies.

Presented at the American Auditory Society Convention, Scottsdale, AZ, March, 2012

Methods

• ***Participants.*** Ten experienced hearing aid wearers (6 females; 4 males) ranging in age from 55-79 participated in this research. Participants wore their own hearing aids during the study.

• ***Methods.*** Twenty-one real-world noisemakers were selected as stimuli. Methods for consistent production of these sounds were developed.

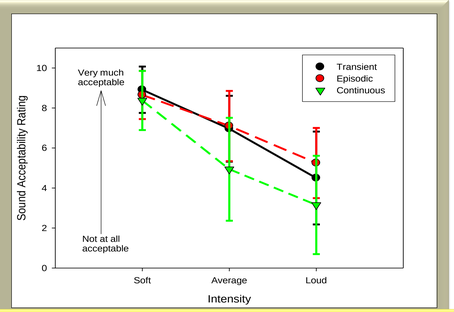
Expanding the research of Hernandez et al (2006) these sounds were evaluated and categorized according to intensity in dB SPL (soft [< 55], average [55-75], and loud [>75]), and duration (transient [< 1 sec], episodic [1-5 sec], and continuous [> 5 sec]). Sound presentation order was randomized within trials. Two trials of sounds were presented systematically in a real-world living room environment to each of the ten participants. Participants rated each sound in terms of acceptability on a continuum from 0 (not at all acceptable) to 10 (very much acceptable). Participants then were asked to propose ideas for other sounds that they encountered in their daily lives that they believed might be useful for this test.

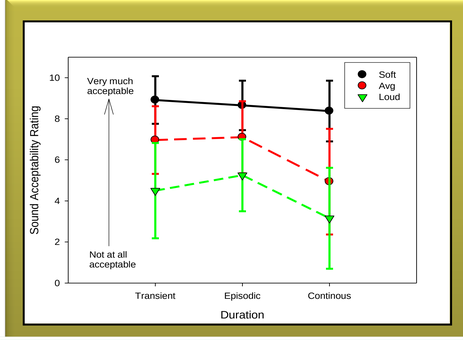
Results

Effects of Duration on Acceptability

❖ Sounds of different durations were perceived as different in acceptability regardless of their intensity (F [2,18]=12.48, p < 001).

❖ Differences in ratings of acceptability averaged across loudness levels were statistically significant for sounds of transient (x = 6.79) and continuous duration (x = 5.489, p = .006), and for sounds of episodic (x = 7.0), and continuous duration (p =.001). No statistically significant differences in acceptability were seen for sounds of transient and episodic duration (p = .48).





Effects of Intensity on Acceptability

❖ Sounds of different intensities were perceived as different in acceptability regardless of their duration (F [2,18]=37.48, p = .001).

❖ Differences in ratings of acceptability averaged across durations were statistically significant for all levels of intensity: soft (x = 8.65) and average (x = 6.33, p = .001); soft and loud (x = 4.302, p < .001); and average and loud (p < .001).

❖ A statistically significant interaction between duration and intensity was found (F [4,36]=2.79, p = .041) with increased duration having a greater negative effect on acceptability for loud sounds compared to soft and average sounds.

Interesting Details

Within-subject variability:

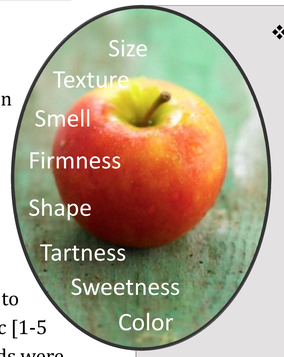
❖ Mean absolute test-retest difference ranged from .3 – 2.55 on a continuum from 0 – 10. Pearson correlation for trials 1&2 ranged from .13 - .95.

❖ Only "Hammer" and "Marbles" had statistically significant differences across trials (Hammer: t (9) = 2.499, p < .05, effect size (r) = .64; Marbles: t (9) = 2.375, p < .05, effect size (r) = .62). These two sounds became systematically less acceptable with repetition.

Between-subject variability:

❖ The standard deviation of mean scores across subjects ranged from 1.01-2.99.

What is Acceptability?



❖ Sound "acceptability" will mean different things to different listeners. We define this concept for our participants using an apple analogy. Instructions for this task and the accompanying analogy were carefully constructed to elucidate the multi-dimensional nature of sounds and their acceptability. In the SAT, acceptability is based on an individual's total impression of a sound. Although related to aversiveness, annoyance, and loudness tolerance, acceptability also comprises aspects of individual experience, preferences, emotional reaction to sound, and perceptions of sound quality, naturalness, clarity, etc

Summary of Results

❖ Generally, increasing duration and/or intensity of a sound corresponds to a decrease in acceptability. Further, increasing duration of a signal decreases the acceptability of the sound more substantially for loud sounds compared to soft and average sounds. These findings support earlier research that suggests transient and steady-state sounds of varying intensities should be included when evaluating sound acceptability.

❖ Subjects' own ratings of acceptability were fairly repeatable across the two trials for the majority of test sounds. Further, each test sound had a range of acceptability ratings across subjects considered sufficient for separating different hearing aid users, or different hearing aid technologies, into groups.

❖ None of the tested sounds were determined to be inadequate for inclusion in this test based on statistical analyses. However, the sound of the compressed-air spray bottle varied in tone and intensity as the bottle emptied. This sound was culled from the test battery.

❖ Participants' answers to the question: "Can you indicate three sounds that you experience in your daily life that we should add to this test?" were considered. Based on these recommendations, the sound of rattling paper was added to the test battery.

Future Directions

Based on these preliminary findings, the SAT is being used in a study comparing different hearing aid conditions. The SAT will be refined at the completion of this study.

References

Hernandez, A., Chalupper, J., & Powers, T. (2006). An assessment of everyday noises and their annoyance. *The Hearing Review, 13*(7), 16-20.

Keidser G, Bentler R, Kiessling J. (2010). A multi-site evaluation of a proposed test for verifying hearing aid maximum output. *International Journal of Audiology* 49(1):14-23.

Acknowledgement

Supported by NIDCD

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