HORIZONTAL LOCALIZATION WITH CROS/BiCROS SYSTEM

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INTRODUCTION

The horizontal localization for the sounds arriving from the sides is based on interaural time difference (ITD) and interaural level difference (ILD) cues. For listeners with asymmetric hearing loss with one unaidable ear these cues are absent. CROS (Contralateral Routing Of Signals) and BiCROS (Bilateral CROS) hearing aid systems enable listeners to hear sounds from both sides of the head when the hearing ability in one ear cannot be helped by traditional hearing aids. A CROS/BiCROS hearing aid system transmits sound from the ear with no functional hearing to a receiver on the ear with normal or aidable hearing. The use of CROS/BiCROS system is used to help the individuals with unaidable hearing on one side to hear better in noisy environments when the desired sound is on the side of the head with no functional hearing. CROS/BiCROS system may also provide environmental awareness by allowing the wearer to hear sounds from both sides. However, the ILD and ITD cues used for horizontal localization are absent even when using CROS/BiCROS system, because all the sounds are presented only to one ear. In this case the listener can only use spectral cues to try to determine the direction of the sound. Further complicating factor when using a CROS/BiCROS system is that the sounds arriving from the contralateral and ipsilateral side have similar acoustic fingerprints. The current study examined the impact of asymmetric hearing loss and the use of CROS/BiCROS system on sound localization performance in the horizontal plane.

WIDEX CROS

WIDEX CROS was developed to meet the needs of people with asymmetric hearing loss with one unaidable ear. WIDEX CROS picks up sounds from the side with the unaidable ear and sends them wirelessly to a receiving hearing aid on the aidable ear. This device can be used in both CROS and BiCROS solutions. WIDEX CROS can be used with every WIDEX DREAM style and model.

The WIDEX CROS mini-BTE includes WidexLink technology which uses near field magnetic induction (NFMI) to transmit the sound wirelessly with extremely low power. WidexLink technology provides robust, distortion free, low delay (<10 ms) audio stream between the CROS transmitter and the receiving hearing aid. The upper limit of the input range is 113 dB SPL.

Omni/Locator microphone
WIDEX CROS includes a choice of omnidirectional or fully adaptive directional microphone on transmitter for further SNR improvements in noise.

Volume control
Volume control (VC) switch on the WIDEX CROS transmitter allows user to adjust for optimal loudness of sounds from the transmitter side.

On/Off transmission
On/Off switch provides listener the freedom to use the WIDEX DREAM in HA or CROS/BiCROS modes to optimize hearing in every situtation.

PowerSaver technology
Low power consumption (0.89 mA) during transmission allows WIDEX CROS users to change batteries less often than the users of other CROS aids.

PARTIPANTS

Six listeners between 63 – 78 yr (mean = 69 yr, SD = 5.5) with asymmetric sensorineural hearing loss (various etiologies) participated in the study. On average, the participants had worn hearing aids for 10.3 yr (SD = 6.4 yr). Five participants had the right ear as the better ear while one had the left ear as the better ear. One participant's pure tone average was about 60 dB HL in the poorer ear, but he was included in the study because his speech discrimination in that ear was poor (20%).

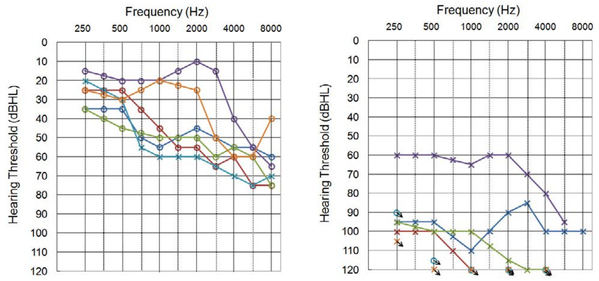

Figure 1: Audiograms for the individual participants.
Better ear (left panel); Poorer ear (right panel).

PROCEDURES

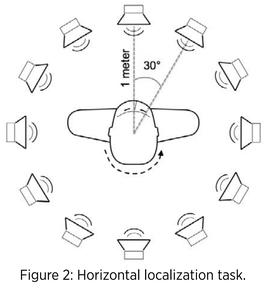

Figure 2: Horizontal localization task.

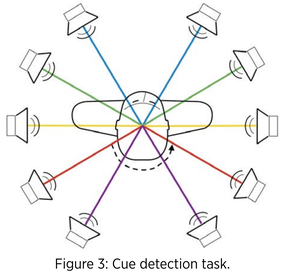

Figure 3: Cue detection task.

Horizontal localization task
The horizontal localization task examined the listeners' ability to identify the azimuth of the sound source. The localization performance was measured in quiet using a 12-loudspeaker array evenly distributed on a horizontal plane. Stimuli was presented from each direction a total of three times in a random order for a total of 36 stimulus presentations. The participant was instructed to indicate the perceived location of the sound. The performance was evaluated aided with and without the CROS, and unaided.

Localization cue discrimination task
The discrimination task examined whether the listeners were able to detect differences in the sound source azimuths. A sound was presented from one loudspeaker followed by the same sound presented from either the same loudspeaker or a different loudspeaker mirrored around 0° (i.e. 30° vs. 330°; 60° vs. 300°; 90° vs. 270°; 120° vs. 240°; 150 vs. 210°). The test consisted a total of 60 comparisons. Participants' task was to indicate if the two sounds originated from the same loudspeaker or the different loudspeakers. The performance was evaluated aided with and without the CROS, and unaided.

HEARING AIDS

Each participant was fitted with WIDEX DREAM Fashion440 BTE hearing aids on the aidable ear and with WIDEX CROS transmitter on the unaidable ear. Hearing aids were fitted with thin tube and instant-fit ear tips.

WIDEX CROS settings:
WIDEX CROS was linked wirelessly to WIDEX DREAM hearing aid. The microphone in the CROS transmitter was in fully adaptive directional mode (Locator). No transmitter gain offset was used.

WIDEX DREAM hearing aid:
WIDEX DREAM is a 15-channel wide dynamic range digital hearing aid. The A/D stage of this device uses a sampling rate of 32 kHz and 20-32 bit resolution. The maximum power output (MPO) is 132 dB SPL and frequency response ranges from 100 Hz to 6750 Hz (ANSI S3.22-2009). The upper limit of the input range is 113 dB SPL. This hearing aid uses slow-acting compression with an attack time of up to 2 sec in each of the 15 channels. Among the features of this device are noise reduction, adaptive feedback cancellation, and impulse noise management. These features remained in their default settings. Microphone was set to fully adaptive directional mode.

STIMULI

Horizontal localization accuracy and horizontal localization cue discrimination ability was evaluated using a 3 second duration full band white noise sequence presented at 68 dB SPL in quiet. The level was roamed by ±2 dB. In the localization cue discrimination task the two stimuli presentations were separated by a 500ms silence.

RESULTS

Horizontal localization
The localization performance was analyzed using a ±30° criterion. Figure 4 compared participants' localization accuracy performance across the three listening conditions. The results demonstrated that the listeners with asymmetric hearing loss with one unaidable ear have poor localization accuracy regardless of the amplification condition. The differences between the different listening conditions were not statistically significant (p>0.05). The participants typically reported the stimuli arriving from the better ear side regardless of the true direction of the sound.

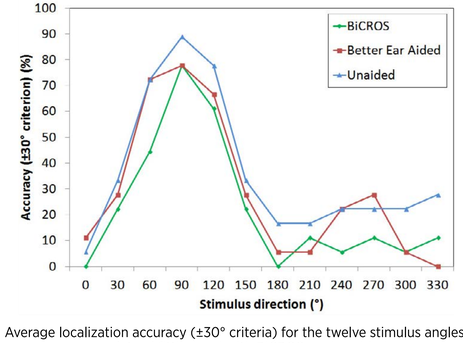

Figure 4: Average localization accuracy (±30° criteria) for the twelve stimulus angles aided with unilateral fitting and with BiCROS, and unaided.

RESULTS (CONT.)

Localization cue discrimination task
The average percent correct responses in the localization cue-detection (same/different) test for different listening conditions across the different stimuli angles was displayed in Figure 5. The use of BiCROS reduced the discrimination performance compared to the unaided condition or when using only hearing aid in the better (impaired) ear. The discrimination scores averaged across all measurement angles were 92.5% (Unaided), 86.1% (Aided), and 78.9% (BiCROS). Participants had the greatest difficulties with BiCROS at ±60° and ±90°. The discrimination performance was still significantly above chance at all angles even when using the BiCROS device. This suggests that the users of BiCROS system have access to monaural localization cues. Unfortunately, the listeners were not able to utilize the cues for correct localization performance as evidenced by the results from the horizontal localization task. Perhaps training could allow these listeners to better use the localization cues to successfully identify the directions of sounds.

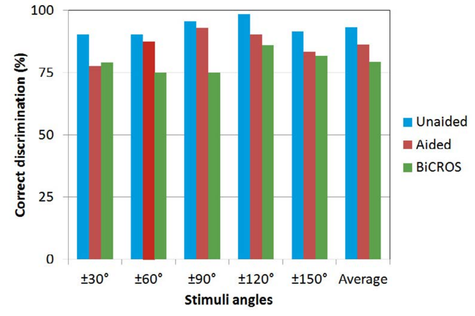

Figure 5: Average percentage correct responses in the localization cue-detection test for different listening conditions.

CONCLUSIONS

The objective of the current study was to determine the horizontal sound localization abilities of listeners with asymmetric hearing loss including single-sided deafness. These listeners do not have access to interaural level and timing cues and therefore have to rely on monaural spectral cues for localization. A further complicating factor when using a CROS/BiCROS device is the absence of the head shadow. The results of the localization task demonstrated that the horizontal localization performance was poor across all listening conditions. The results of the cue detection task on the other hand demonstrated that the participants were able to hear differences in sounds presented from various angles. This was true even when wearing a CROS/BiCROS device. Perhaps the CROS/BiCROS wearers could be trained to successfully use the monaural cues for localization by strengthening the association of the auditory cue with its spatial correlate. Kuk et al (2014) have demonstrated efficacy of a localization training program designed for hearing impaired listeners. Training CROS/BiCROS wearers to localize sounds requires additional research.

REFERENCES

Kuk F, Keenan D, Lau C. (2014) Evaluation of a localization program for hearing impaired listeners. *Ear Hear* in review.