

# Can Extended High Frequency Thresholds Be Used To Detect Auditory Processing Difficulties In An Aging Population?

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## Introduction

Hearing impairment can profoundly affect people's lives. It can lead to isolation and depression, lower quality of life and deteriorating relationships, particularly for older people [1]. An emerging concern relates to a subset of older adults who present with peripherally normal hearing but complain of persistent difficulties to understand speech in acoustically challenging environments [2]. This phenomenon is often referred to as "obscure auditory dysfunction" [3-5]. However, the term "obscure" is misleading, as it is estimated that this group make up an estimated 10-15% of all audiological referrals [6].

At present in the UK, hearing loss is diagnosed on results of the "auditory profile". This is derived from a subjective hearing assessment (pure tone audiometry, PTA) across a conventional frequency range of 0.25-8 kHz. Although frequencies below 8 kHz are known to be most important for speech intelligibility, higher frequencies (> 8kHz) also have an important role in providing speech cues [7]. Therefore the current approach of diagnosing hearing loss based solely on conventional audiometry thresholds alone is inherently flawed.

It is plausible that poor speech perception in older adults could reflect an ultra-high frequency hearing loss and the subsequent masking of any speech information that may be carried above 8kHz by low frequency ambient noise [8]. This is supported by studies that have shown that an upward spread of masking in patients with a high frequency hearing loss results in poorer speech discrimination [9, 10]. However to date there have been very few studies that have investigated the role of extended high frequencies in older listeners. In the present study, we compared pure tone thresholds for frequencies from 250 Hz to 20 kHz in older adults, with and without self-reported auditory complaints. Our aim in this pilot study was to detect any consistent differences that may exist between the two groups and to examine the potential usefulness of measuring extended high frequencies in an aging population.

## Methods

### *Subjects*

Eighteen subjects (age range 50-67 years, mean 55 years, 8 male) were recruited from a larger study [11]. Subjects were recruited once normal peripheral hearing was established. Subjects were selected on the basis of the following criteria: (a) audiometrically normal hearing, defined as a negative otologic history, normal findings on impedance test, and auditory thresholds of  $\leq 20$  dB HL at all standard audiometric

frequencies (0.25, 0.5, 1.0, 2.0, 4.0, and 8.0 kHz in the worse ear); (b) no obvious causes such as CNS pathology, ototoxic drug intake; (c) no signs of conductive pathology (d) other psychological factors. Ethical Committee approval was obtained for the study with informed consent obtained from each subject.

## ***Procedures***

### *Conventional Pure Tone Audiometry (CF)*

Auditory sensitivity was measured using standard clinical pure tone audiometry in accordance with the British Society of Audiology recommended procedure [12]. An audiometer (model GSI 61; Grason-Statler, Milford, NH) recently calibrated with earphones equipped with TDH-49 cushions was used. Air-conduction thresholds were measured for each ear at 0.25, 0.5, 1, 2, 4, and 8 kHz, with testing repeated at 1 kHz.

### *Extended high frequency audiometry (EHF)*

EHF thresholds were established at intermediate frequencies between 9 and 20 kHz (9, 10, 11.2, 12.5, 14, 16, 18 and 20 kHz) using a modified Hughson-Westlake procedure [13]. The test tones were presented as continuous tones in both frequency ranges with a step width of 5 dB. The circumaural earphone HDA 200 (Sennheiser Co., Germany) was used in conjunction with the audiometer GSI 61 (Grason Statler). The minimum adjustable level was about -20 dB HL at all frequencies in the extended high frequency range and the maximum adjustable level varied from about 100 dB HL at 9 kHz to about 20 dB HL at 20 kHz.

## **Results**

Subjects were divided into two groups: group 1 reported difficulties with their hearing in background noise (n=7) and group 2 reported no concerns (n=11). All participants had normal peripheral hearing across 0.5 kHz to 4 kHz. Figure 1 summarises group variance measures. Significant differences were observed between the two groups for the extended high frequencies (9-20 kHz) only. Older adults with self-reported difficulties (group 1) had statistically significant increased hearing threshold levels only in frequencies higher than 9 kHz (Kruskal-Wallis chi-squared test,  $df=1$ ,  $p < 0.05$ ). Interestingly, those with self reported difficulties had elevated thresholds across all of the frequency range (Figure 1). Other studies have reported similar results in a smaller group of patients (n=9) with self-reported speech-in-noise difficulties [8].

## **Discussion**

In this paper we have clearly shown that older adults with self-reported hearing difficulties on average have worse hearing threshold levels over the entire audiometric range (0.25-20 kHz) when compared with older subjects who don't have any self-reported problems. However, since all average thresholds for both groups lie within the normal range within conventional audiometry (0.25-8.0 kHz), it is possible that this hearing loss remains undetected, as EHF audiometry is not routinely used.

Our data suggests that the poor speech perception reported in these subjects could arise from a loss in the ability to utilise EHF information. This could interfere with frequency resolution abilities, or alternatively it may interfere with temporal resolution abilities as in gap detection tasks. Upward spread of masking and remote masking have previously been investigated in subjects with high-frequency hearing losses. These

studies demonstrate that speech reception in noise for spread of masking and levels of hearing loss could affect listeners with a high-frequency hearing loss [10].

The reduction in audible high-frequency speech information has provided only one explanation. The complexity of auditory processing and the inherent redundancy seen in the central auditory pathways would suggest that an EHF hearing loss alone cannot account for the auditory deficits seen in older listeners. Rather it is likely that deficits in the EHF have a contributory role that warrant further study.

What is clear is that measurement of auditory sensitivity from 9 to 20 kHz provides essential information that often is not predictable from conventional audiometric measurement. In summary, although our sample size is small, there is significant evidence for the use of EHF in adults who report difficulty hearing in complex background noise. Should future studies show similar findings, then there is a urgent need to reconsider current audiometric descriptors.

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**Figure caption**

**Figure 1.** Top panel. Average hearing thresholds for conventional (0.25 – 8 kHz) and EHF (9-20 kHz) range showing the minimum, maximum and median values (solid bar).