Audio for Virtual Reality
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Individuality of HRTFs

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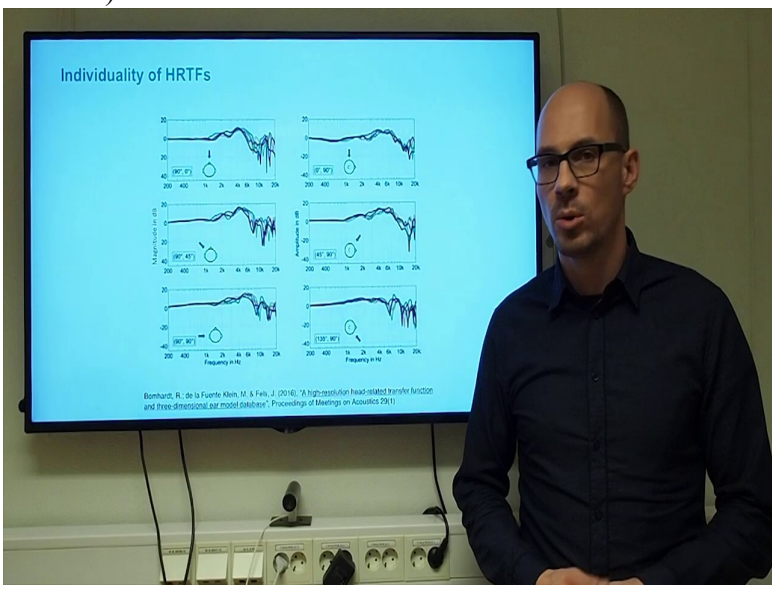

An important thing to note with head related transfer functions and binaural auditory reproduction is the fact that head related transfer functions are individual, meaning they are different for different people.

Everybody has the different shape of the head, different size of the head,

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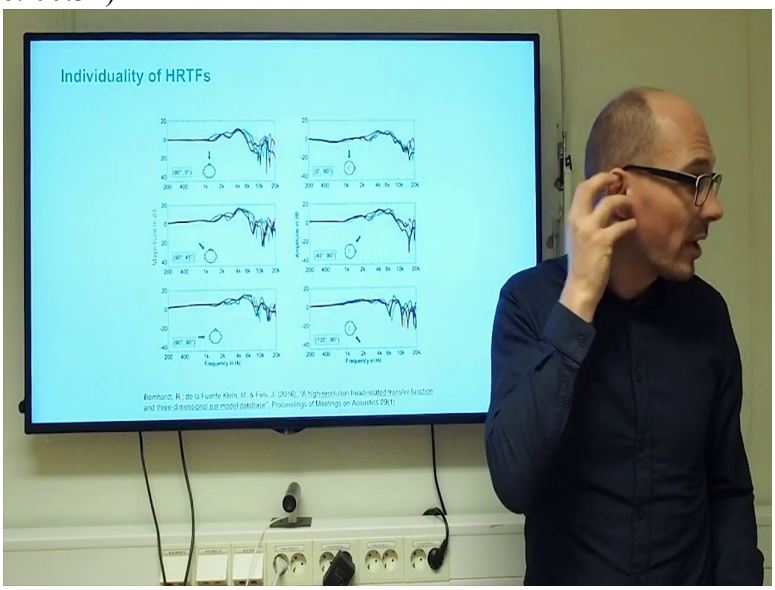

different location of the ear, different angle of the ear, the size of the ear can be different and the geometry of the ear can be different, so that each person will experience different acoustic localization cues in their everyday life.

And so if the system uses another person's head related transfer functions to perform binary reproduction the auditory system of the user might be provided with cues that it does not understand so well and this can lead to incorrect localizations of the elevation for example or it can lead to front-back confusions if they are not resolved with dynamic cues.

To give an idea how different the HRTFs of different individuals can be, I added this chart. Each

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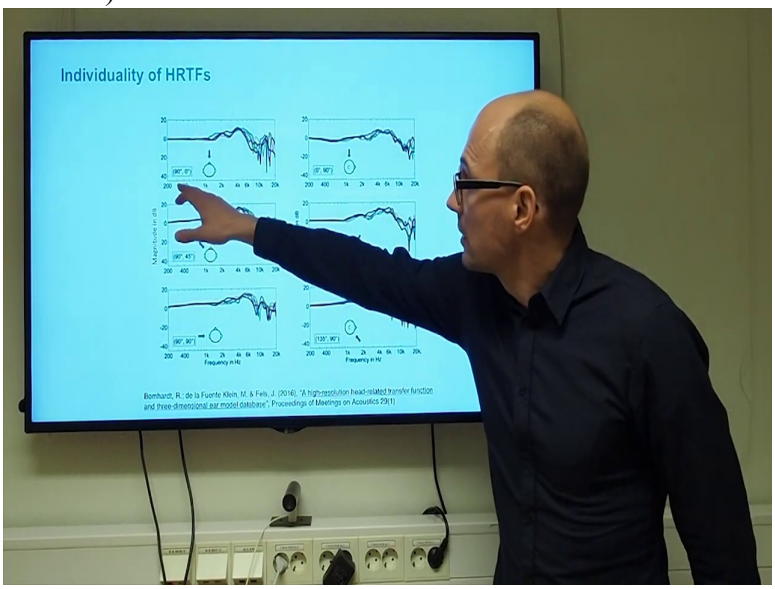

of these charts shows horizontal axis on a source of frequency on horizontal axis and the magnitude of the head related transfer function for a specific sound source location on a vertical axis and the HRTFs of different people are different, are plotted in different colors.

So for frontal

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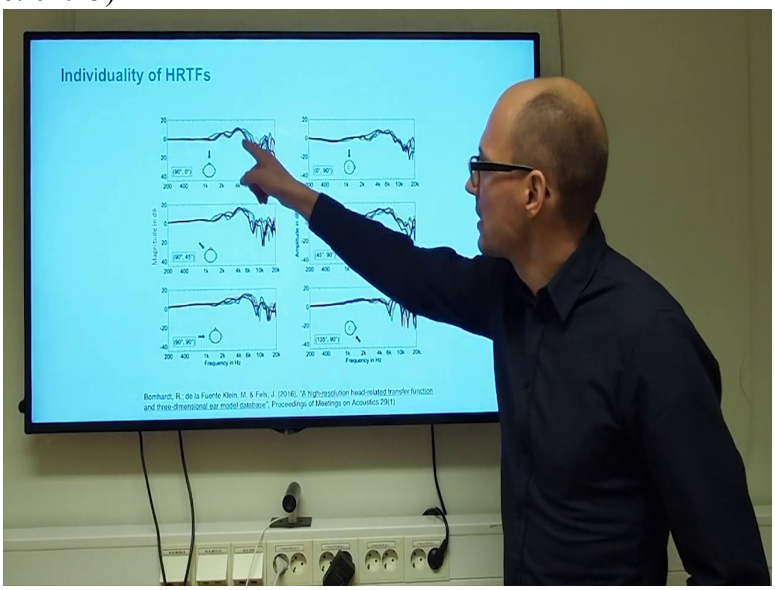

sound incidence for example, you can see that there are certain individual changes in the frequencies between 1 or 2 kilo Hertz already and particularly at higher frequencies where the wavelength is short by the geometry of the ear is in the same order of magnitude.

Similarly for more lateral

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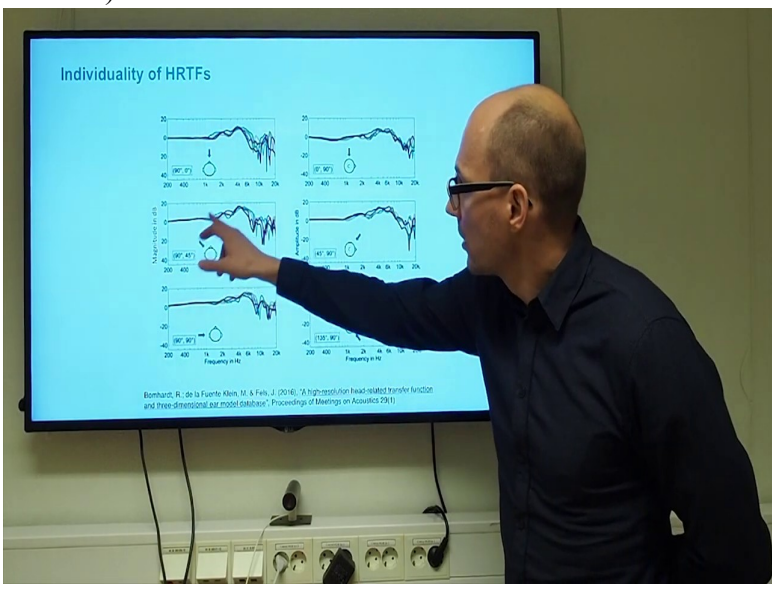

incidence we have also spectral differences that are yet different than for frontal incidence.

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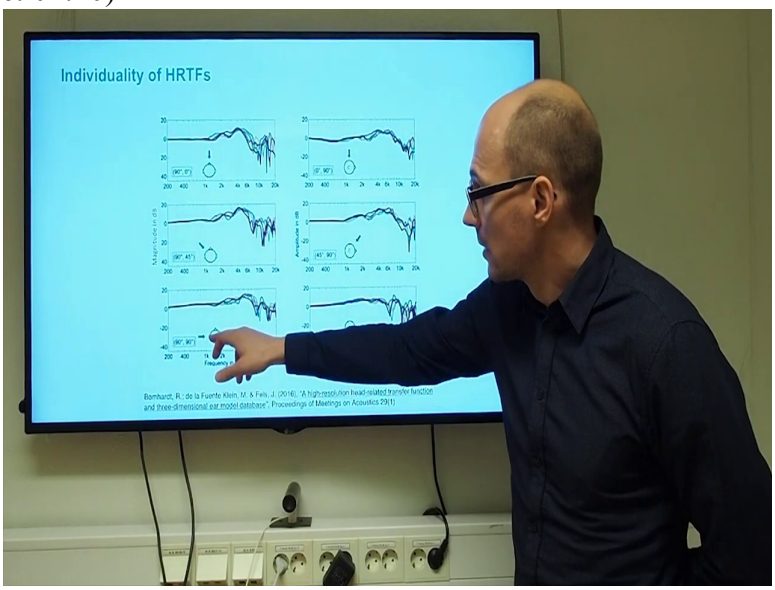

This is 90 degree incidence and this, these charts they show the same situation for different elevations and sound source inside at the median plane.

So one way to overcome this is simply measure the head related transfer function of the user which is of course costly and time consuming.

Another way

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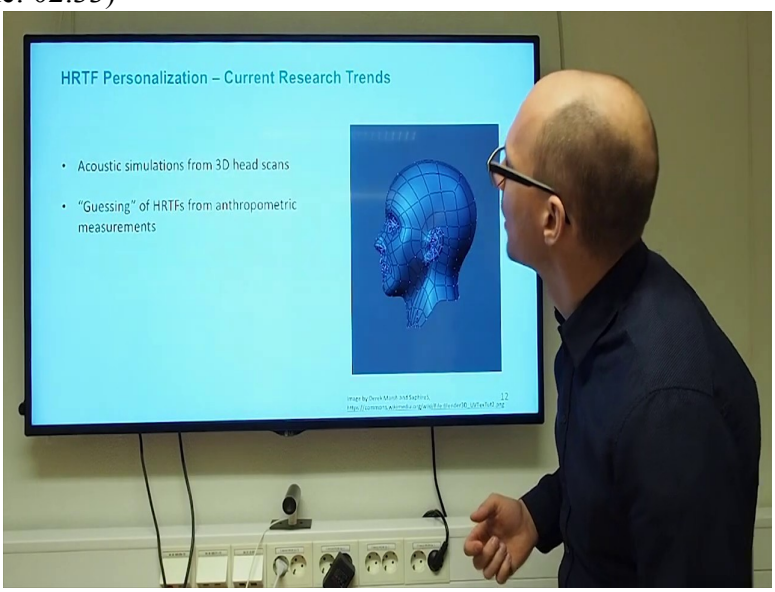

is measuring, scanning the geometry of the user's head and then computing the head related transfer functions that correspond to this geometry which is suitable method. And this is something that is actively researched at the moment and results are promising.

But they are not fully convincing yet. So this is something that will take couple of more years until it will be readily available so that you can for example simply take a picture of your ear and plug-in would compute the head related transfer functions that correspond to this ear geometry.

Another means of HRTF personalization would be guessing the head, something measuring the anthropology, the, the anthropological features of a ear and then picking just the suitable head related transfer function out of the larger database that was previously measured. And so you basically guess the HRTF that might, might match or might suit the user based on similar anthropology of the ear.

And this is of course, how other works depends very much on how, what the database is being used and how the individual HRTFs are selected.

There is still a lot of ongoing research on this so the ultimate solution is not available. Fortunately

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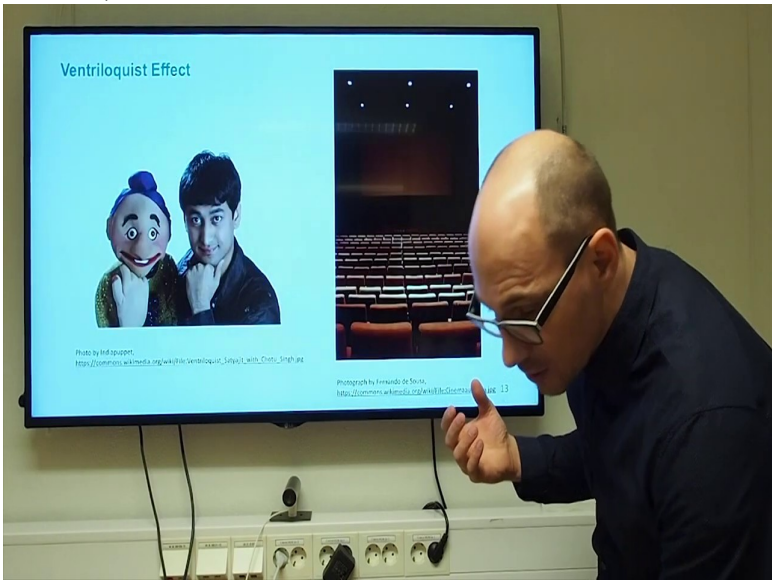

it not even necessary to have a perfectly matching HRTF in many ways because of what is called the ventriloquist effect.

In virtual reality usually the audio is accompanied by visuals and that the localization in vision is much more reliable than when it comes to sound.

So for example, so that if there is a contradiction or if between the visual localization and the auditory localization or simply if there is a very strong visual localization cue then that will determining where we are hearing something.

Very prominent example is a puppeteer who, who makes the mouth of the puppet move in synchrony with what this person, what the puppeteer is saying and the puppeteer is talking such the mouth does not move, so you only hear the sound or the voice and you see the puppet's mouth moving and this will automatically make you localize the voice inside the mouth of that puppet although it originates from the puppeteer.

This is called the ventriloquist effect and it is, you can experience this in everyday life, for example with the television or a cinema where the loudspeakers were never, only few of the loudspeakers would be located behind the screen

But if you see somebody talking for example on the screen and the sound of that voice is being played from a loudspeaker at another location that is not too far away then you will localize the sound of the voice at that position where the mouth is moving if you pay attention.

So it is not a very strong effect and if you pay attention and focus on localizing the sound you might notice the discrepancy between the visual localization and the sound or especially if you close your eyes you might notice that you suddenly hear the sound from a different location.

But still if you are not paying attention, if you are not focusing strongly then this works very well and the visual cue pulls the auditory localization to the correct location.