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# Short communication
# False localization of TMJ sounds to side is an important source of error in TMD diagnosis

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Sounds from one jaw joint may be heard and recorded also on the contra-lateral side. The side of origin then has to be determined by comparing the sounds' time-frequency characteristics as described by Widmalm *et al*. (1997). More information is needed about how the sounds are affected when propagated through the head tissues to improve the methods for such discrimination. The **hypothesis** was that the head tissues act as a filter causing attenuation of the joint sounds and phase shifts of their sinusoids that may vary for different frequencies. The **aim** was to compare bilateral recordings of unilateral sounds to estimate the head tissues' filtering effects.

## Methods

Bilateral recordings ($N = 80$) were made from two subjects with unilateral TMJ sounds.

Microphones (Sony ECM-77B), bandwidth 40–20 000 Hz, placed in the external auditory canals were used for recording to a digital tape recorder (Tascam DAT-30). The sampling rate was 44 100 Hz. The transfer function $H(f)$ of the head tissues was calculated as follows: $o(t) =$ the original sound; $e(t) =$ the sound recorded on the contra-lateral side; $O(f) =$ the Fourier transform of $s(t)$; $E(f) =$ the Fourier transform of $e(t)$.

Next, for each sound pair,

$$S^k oo(\mathrm{f}) = O(f)O^*(f)$$

and

$$\mathrm{S}^k oe(f) = E(f)O^*(f).$$

The transfer function $H(f)$ can be rigorously estimated for $N$ records as described by Williams, Gesink and Stern (1972):

$$H(f) = \frac{\sum_{k=1}^{N} S^k oe(f)}{\sum_{k=1}^{N} S^k oo(f)}.$$

If $H(f)$ is assumed to be complex valued and equal to $A(f) + iB(f)$, then the magnitude of $|H(f)| = (A(f)^2 + B(f)^2)^{1/2}$ and the phase $H(f) = \tan^{-1}(B(f)/A(f))$.

## Results

The head tissues acted as a band pass filter with large variations in magnitude response. Areas with relatively small attenuation (20–40%) alternated with areas with strong ($>90\%$) attenuation. Frequencies between $\sim 600$ Hz and up to approximately 1000 Hz were strongly attenuated. There were negative phase shifts up to about 12 radians, larger for high compared to lower frequencies. The contra-laterally recorded sounds were delayed in relation to the original sounds about 1 ms or less which is consistent with the negative slope of the phase versus frequency plots.

## Summary

The results of the study indicate that the head tissues act as a band pass filter that is far from flat. Instead there seems to be strong frequency variations in attenuation of transmitted sounds. The sounds are subject to phase shift and time delay, which can be used to decide from which TMJ the sound comes. Bilateral electronic recording with high sampling rate ($\gg 44$ kHz) is needed to accurately and consistently identify the origin of a TMJ sound. Further studies on autopsy specimens and large subject groups are motivated.

## References

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